PROCEEDINGS

of the

American Society

for

Horticultural Science

1920

SEVENTEENTH ANNUAL MEETING

W. H. Alderman

PROCEEDINGS

OF THE

AMERICAN SOCIETY

FOR

HORTICULTURAL SCIENCE

1920

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CONSTITUTION*

ARTICLE I

The name of this Association shall be the American Society for Horticultural Science.

ARTICLE II

The object of the Society shall be to promote the Science of Horticulture.

ARTICLE III

Any person who has a baccalaureate degree and holds an official position in an agricultural college, experiment station, or Federal or state department of agriculture in the United States or Canada, is eligible to membership. Other applicants may be admitted by vote of the executive committee.

ARTICLE IV

Meetings shall be held annually at such time and place as may be designated by the Executive Committee, unless otherwise ordered by the Society.

ARTICLE V

The officers shall consist of a President, three Vice-Presidents, and a Secretary-Treasurer, who, together with the chairman of the standing committees, shall constitute a Council to act upon all applications for membership. There shall also be an Assistant Secretary. These officers shall be elected annually by ballot.

ARTICLE VI

This Constitution may be amended by two-thirds votes of the Society at any regular meeting, notice of such amendment having been read at the last regular meeting.

BY-LAWS

SECTION 1. The President and other officers shall perform the usual duties of their respective offices. The President shall also deliver an address at each regular meeting.

SEC. 2. There shall be a Committee on Nominations consisting of five (5) members, who shall be nominated and elected by ballot at each regular meeting of the Society. It shall be the duty of this committee, at the following meeting, to suggest to the Society names for officers, referees, and members of committees for the ensuing year.†

SEC. 3. There shall be an Executive Committee, consisting of three (3) members and the President and the Secretary, ex-officio. This committee shall perform the usual duties devolving upon such committee.

SEC. 4. The Committee on Nominations shall nominate referees and alternates upon special subjects of investigation or instruction, which may be referred to its consideration by the Society. The duties of these referees shall be to make concise reports upon recent investigations or methods of teaching in the subjects assigned them, and to report the present status of the same.

SEC. 5. There shall be a Committee on Program, consisting of seven (7) members, of which the Secretary shall be one. This committee shall have charge of the scientific activities of the Society, except as otherwise ordered by the Society.

SEC. 6. The annual dues of the Society shall be two dollars and fifty cents.

SEC. 7. Ten members of the Society shall constitute a quorum.

*The Constitution and By-Laws as amended from time to time.
†Since 1918 two lists of candidates have been required.

MEMBERSHIP ROLL FOR 1920

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ANDERSON, O. G. ... Purdue University, Lafayette, Ind.
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TREASURER'S REPORT FOR 1920

Voucher No.	1920	Cr.		
	Jan. 9	Stamps		$2.00
	Jan. 16	Stamps		2.00
(1)	Jan. 31	Express on Manuscript of 1919 Report		.35
	Feb. 3	Stamps		1.00
	Feb. 17	Postage and insurance on letterheads and envelopes to officers		1.44
(2)	Feb. 24	J. R. Risdon, Riverdale, Md.		
		2,000 letterheads	$8.65	
		2,000 envelopes	10.00	
				18.65
	Mar. 3	Stamps		1.00
(3)	Mar. 23	Maurice Joyce Engraving Co., Inc., Washing-ington, D. C.		
		3 copper half-tones	$13.63	
		5 line engraving	16.02	
				29.65
(4)	Mar. 23	Chas. G. Stott & Co., Washington, D. C. 600 No. 70 Columbia Clasp Envelopes		11.10
	Mar. 24	Stamps		1.00
	Apr. 7	Stamps		1.00
	Apr. 29	Stamps		1.00
(5)	May 18	Express on 1919 Reports from printer in Geneva, N. Y		2.85
	June 1	Stamps		1.00
	June 8	Stamps		4.00
	Aug. 23	Stamps		1.00
(6)	Aug 26	Reprints of membership roll and constitution	$2.50	
		Postage	.07	
				2.57
	Oct. 12	Stamps		1.00
	Oct. 26	Stamps		1.00
(7)	Nov. 7	W. F. Humphrey, Geneva, N. Y.		
		Printing 1919 Report, 351 copies of 210 pages at $1.82 per page	$382.20	
		One insert	5.00	
		$6\frac{2}{3}$ hours author's alterations at $1.00 per hour	6.67	
		89,640 ems excess composition at $1.00 per 1,000 ems	89.64	
		Stamps for mailing reports	15.19	
		Two hours' mailing at 55¢	1.10	
		Special delivery on proof, 2 lots	.20	
				500.00
	Nov. 10	Stamps		5.00
	Dec. 11	Stamps		3.50
(8)	Dec. 20	J. R. Risdon, Riverdale, Md. Printing 300 programs for 1920		22.00
		To Balance		140.22
		Total		$754.33

1919	Dr.	
Dec. 29	By Balance	$301.78
1920		
Jan. 24	Missouri Fruit Experiment Station, Mountain Grove, Mo., reports 1905 to 1918, inclusive, except 1911	$13.50
Jan. 28	E. J. Kraus, Madison, Wis., reports for 1905, 1906, 1907, 1908 & 9, and 1910	5.00
Mch. 3	A. C. McClurg & Co., Chicago, Ill., reports for 1916, 1917 and 1918	4.50

Mch. 3	H. A. Phillips, Ithaca, N. Y., report for 1919	$1.50
Mch. 24	American News Co., Inc., New York City, report for 1917	1.50
Mch. 31	Paul C. Stark, Louisiana, Mo., reports for 1907 to 1918, inclusive, except 1911	11.50
Mch. 31	Baltimore News Co., Baltimore, Md., reports for 1916, 1917 and 1918	4.50
Mch. 31	Royal Horticultural Society, London, England, report for 1918	1.50
June 1	State Department of Agriculture, Harrisburg, Pa., report for 1919	1.50
June 1	F. E. Neer, Davis, Cal., report for 1919	1.50
June 1	R. Veterinary and Agricultural College, Copenhagen, Denmark, report for 1919	1.50
June 1	Southern Florist Publishing Company, Ft. Worth, Texas, reports for 1917 and 1918	3.00
June 30	State College of Washington, Pullman, Wash, report for 1919	1.50
June 30	Princeton University, Princeton, N. J, report for 1919	1.50
June 30	U. S. Experiment Station, Honolulu, Hawaii, report for 1919	1.50
June 30	Arnold Arboretum, Jamaica Plain, Mass., report for 1919	1.50
June 30	Oregon Agricultural College, Corvallis, Ore., refund on two cuts for 1919 report	10.05
June 30	Experiment Station, Blacksburg, Va., report for 1919	1.50
July 7	Southern Florist Publishing Company, Ft. Worth, Texas, report for 1919	1.50
July 7	University of Vermont, Burlington, Vt., report for 1919	1.50
July 7	State Agricultural College, Fort Collins, Col., report for 1919	1.50
July 7	Kentucky Agricultural Experiment Station, Lexington, Ky., report for 1919	1.50
July 7	Oregon Agricultural College, Corvallis, Ore., report for 1919	1.50
July 12	Purdue University, LaFayette, Ind., report for 1919	1.50
July 13	Georgia State College of Agriculture, Athens, Ga., report for 1919	1.50
July 15	Cornell University, Ithaca, N. Y., report for 1919	1.50
July 20	University of California, Berkeley, Cal., three reports for 1919	4.50
July 20	Georgia Agricultural Experiment Station, Experiment, Ga., report for 1919	1.50
July 29	Agricultural College, Amherst, Mass., report for 1919	1.50
Aug. 2	University of Minnesota, St. Paul, Minn.. report for 1919	1.50
Aug. 3	Cornell University, Ithaca, N. Y, reports for 1905, 1906, 1907, 1912, 1913, 1914, 1915, 1916, 1917, 1918 and 1919.	13.00
Aug. 3	Iowa State College, Ames, Iowa, report for 1919	1.50
Aug. 23	University of Missouri, Columbia, Mo., report for 1919	1.50
Aug. 23	Brooklyn Botanical Garden, Brooklyn, N. Y., report for 1919	1.50
Aug. 24	A. C. McClurg & Co., Chicago, Ill., report for 1919	1.50
Aug. 26	Southern Oregon Branch Station, Talent, Ore., report for 1919	1.50
Aug. 31	Seattle Public Library, Seattle, Wash., reports for 1916, 1917, 1918 and 1919	6.00
Sept. 2	Utah Agricultural College, Logan, Utah, report for 1919	1.50
Oct. 6	Dulan & Co., Ltd., London, Eng., reports for 1915, 1916, 1917, 1918 and 1919	7.00
Oct. 12	W. E. Lake, Mervin, Saskatchewan, reports for 1905 to 1919, inclusive, except 1911	15.00
Oct. 15	University of Maine, Orono, Me., report for 1919	1.50
Oct. 15	University of Illinois, Champaign, Ill., report for 1919	1.50
Oct. 19	H. C. Thompson, Ithaca, N. Y., report for 1916	1.50
Nov. 3	University of Wisconsin, Madison, Wis., report for 1919	1.50

Nov. 9	University of West Virginia, Morgantown, W. Va., reports for 1912 to 1919, inclusive	$10.00
Dec. 11	Louisiana State University, Baton Rouge, La., report for 1919	1.50
Dec. 11	Kansas State Agricultural College, Manhattan, Kas., report for 1919	1.50
Dec. 11	University of California, Berkeley, Cal., reports for 1905 to 1919, inclusive, except for 1911	15.00
Dec. 20	Brentano's Washington, D. C., reports 1917, 1918	3.00
	Annual Dues paid since last meeting	276.00
	Total	$754.33
	Balance on hand	$140.22

Respectfully submitted,

C. P. Close, *Treasurer.*

The Auditing Committee reported that it had examined the accounts of the Treasurer and found them to be correct.

E. C. Auchter,
R. W. Rees,
W. G. Brierley,
Auditing Committee.

ANNUAL MEETING AT CHICAGO, ILL.

December 29, 30 and 31, 1920

President Alderman called the meeting to order and presided throughout the sessions. The program was crowded, but by holding the speakers to the twenty-minute time limit, the papers were handled satisfactorily and there was ample time for discussion.

In point of attendance this was the banner meeting of the Society, and in point of snappy papers full of substance, this program has never been excelled. Our visitors were delighted with the high quality of the addresses and commented favorably upon the large number of young men present, in fact, ours seemed to be *the* society of young men. Only three charter members were present, namely Beach, Close and Stuart.

Fruit Breeding in the Northwest and Its Significance in Horticultural Development

By S. A Beach, *Iowa State College, Ames, Iowa.*

THE term Northwest as used in the title is intended to bear the significance which it had a generation or two ago. It does not refer to the Pacific Northwest, but rather to that portion of the great central plain of the North American continent, which, approximately speaking, has for its southern boundary the Platte River from the Rocky Mountains eastward to its junction with the Missouri a few miles below Omaha, and a line extending from the mouth of the Platte River eastward across Iowa and Illinois to the southern extremity of Lake Michigan. From this southern limit the Northwest of our theme extends northward to the Canadian border and beyond in a rather undefined way into the agricultural districts of the Great Plains in Canada.

This is a region of much natural wealth and really great resources. Stimulated by the genius of our Christian civilization and under the beneficent governments of the United States and Canada, this is destined to become one of the most populous, resourceful and highly civilized areas of the globe. Its present population is perhaps 15,000,000. By 1950 it may well be double that number. Eventually it will sustain a much greater population than that.

Even now its per capita production of wealth and purchasing power is high, with a corresponding demand for the necessities,

comforts and luxuries of American civilization. Withal, there is a growing appreciation of and an increasing demand for horticultural products. It consumes annually millions of dollars' worth of fruit and fruit products over and above what it produces. Even in the remoter parts in Canada the shop windows in the little railroad towns display bananas and citrus fruits in addition to the apples and other fresh fruits of the temperate zone, together with the staple canned and dried fruits and various lines of fruit products. The increase in wealth and population will naturally be accompanied with more or less growth along various horticultural lines, including pomology.

It is now more than fifty years since the first transcontinental line of railroad was completed across this territory. Now there are several such lines, including two through the Canadian Northwest. The more important sections are covered by a network of railroads. During these fifty years the more important agricultural areas have become covered with farm homes and with the cities and small towns which have been built out of the agricultural wealth of the region. On these farms, or in these village and suburban homes, somewhere, at some time or other, and generally speaking, repeatedly in many times and many places, practically all of the standard fruits and many of the amateur sorts of the eastern states and of west Europe, have been planted. Most of these have failed because of inability to withstand the climatic extremes of this Central Plains territory.

The struggle for existence and survival of the fittest has brought out some varieties which show superior hardiness. It must be confessed, however, that practically none of these very hardy varieties produce fruit which can successfully compete with standard commercial sorts in the general markets of the country. In the more favored areas a very few standard market varieties of apples and sour cherries are grown commercially, but practically none of the standard market plums, sweet cherries, peaches, quinces, pears or other orchard fruits. The few standard varieties of apples and sour cherries referred to are more or less deficient in hardiness and are comparatively short-lived here.

There have been originated here, or brought into the region and found to have more or less local adaptation, enough varieties to make it possible for the people to grow a considerable amount of fruit, which, even if it is not of standard commercial type, is of considerable local value. These fruits have been supplemented in the case of stone fruits by native varieties and hybrids of plum and sand cherry. At least one of the hybrid apples thus originated, the Wealthy, has been quite widely planted outside of this region and in its season has a recognized standing in general markets. However, the commercial fruit growing situation may be summed up by saying that the region as a whole produces but a comparatively small amount of fruit that finds its way into the general markets of the country. Since it consumes vastly more fruit than it produces, its fruit growing industry affects the general fruit trade

chiefly by lessening the home demand for fruit to be shipped in through the general trade.

FRUIT BREEDING IN THE UPPER MISSISSIPPI VALLEY AND NORTHERN PLAINS

In the development of fruits adapted to this region there has been in the aggregate a considerable amount of work done by private parties. Some of this has consisted simply of testing of chance seedlings by nurserymen. In many cases the seedlings from mixed seed of unknown, or not definitely known parentage, have been selected for testing, as for example when a nurseryman, noticing a fine appearing tree among his seedling stocks would transplant it to the orchard. In some cases seeds were selected from desirable fruit, but since the blossoms had been unguarded the pollen parent was not known with certainty, as in the case of the Wealthy apple. A few have gone farther than this and have actually cross-pollinated the blossoms. Sometimes mixed pollen of selected varieties, without emasculating the blossom, has been applied to the stigma But very few of these private workers have carried on this work under control conditions such that both parents of the seedling are definitely known and recorded. These workers are worthy of high commendation for their services in helping to develop hardy varieties adapted to the region. In some instances the enthusiasm of these private individuals has led them to put time and money into this line of work for which they have never received adequate financial compensation, and which has even brought financial loss Their real compensation is in the satisfaction which comes from an honest endeavor to serve.

With the establishment of experiment stations in the several states under the Hatch act, in 1888, and in the case of the Iowa Experiment Station under the leadership of Professor J. L. Budd even two or three years prior to that, the official horticulturists began to give some attention to fruit breeding. Sometimes this was done in co-operation with the state horticultural societies. The earlier efforts were often desultory, often lacked good foresight, and almost always, if not always, they lacked proper facilities, adequate financing, and support, and continuity. Out of them, however, have come desirable results, first in producing technically trained men to carry forward the work, and second, in helping to secure for the work needed recognition and support. It has come to be quite generally recognized that in order to have fruit breeding investigations on the most satisfactory basis, they should be carried forward as definite projects by state or federal institutions such as our agricultural experiment stations.

There are many obstacles to fruit breeding in the Upper Mississippi Valley and Central Plains region.

First, there are the natural obstacles to the rapid development of desirable varieties of fruit which are well enough adapted to the region to be reliably hardy and dependable croppers. Second, those obstacles in the way of developing a strong popular appreciation of the value and importance of this work, and a public

sentiment which will demand that the work be provided with properly qualified technical experts, laboratory and greenhouse equipment, land, and money necessary to stabilize the work, give it continuity of purpose and personnel, and put it in position to push forward rapidly towards the possible achievements of scientific fruit breeding for the service of this great region.

Attention to the matters pertaining to adequate financing and equipment of the work is perhaps of the most immediate importance. However, we shall not, in the limited time assigned to this paper, attempt a further discussion of them here. Rather we will turn out attention to a brief consideration of some of the outstanding features in the natural obstacles. One of the most important is the lack of hardiness in the types which are most desirable in quality, style and season of edible maturity. This brings us to a brief consideration of the problem of hardiness.

The Hardiness Problem

By hardiness, as the term is here used, is understood the ability of the plant or tree to endure climatic environment with practically no injury either in root or top.

In the well-developed fruit regions of the East, of the Rocky Mountain and Inter-Mountain ccountries, and of the Pacific Northwest, the hardiness problem is given but little consideration by the practical growers for the reason that they have enough hardy standard market varieties to meet their needs.

In the Upper Mississippi Valley and Great Plains regions it is otherwise. Take the apple for example. In those portions of this region where the apple can be grown commercially, it is unusual to find mature, bearing, commercial orchards with a perfect stand of trees. More often there will be found less than 50 per cent of the original planting. The domestic orchards, which comprise the great bulk of the apple trees grown, are seldom in better condition. Usually they are worse. Excluding crabapples from consideration, it may be said that superior hardiness is found most highly developed in Hibernal and others of its type. It is said that Hibernal can be fruited as far north as Winnipeg, but Professor Thomas McCall reports that even this variety has not proven reliably hardy at the Crookston School of Agriculture in the Red River Valley in northwestern Minnesota. Some of the crabapple types are superior to the Hibernal group in hardiness and the crabapples may be successfully hybridized with the apple. Here then is presented one problem for apple-breeders, that of finding to what extent hardiness in the apple and in the crabapple can be segregated and recombined with other desirable characters, and what varieties can best be depended upon as parents to transmit these characters as pure line characters.

Throughout the northern portion of that part of the corn belt which is included in the region under consideration, the planting list of reliably hardy varieties includes some good summer and early autumn apples. These are principally either crab hybrids, or apples of the Russian group. For northern Iowa,

southern Minnesota, and adjoining regions of similar climatic environment, there is such a dearth of late autumn and winter apples of standard quality that the output of this vast region, of fruit of that class which finds its way into general markets outside this region, is practically, if not absolutely, nil.

Along the southern limits of this region, that is to say in the belt of country included in north-central Illinois, parts of southern Wisconsin, central and north-central Iowa, and east-central Nebraska, there is a limited commercial production of such standard winter apples as Ben Davis and its kin, Jonathan, and Grimes, with a few others for which there is less demand, such as Rambo, Ralls, Minkler, Willow Twig, Salome and Northwestern Greening. The only ones of this list which can really compete in the general markets with the high class varieties of the East and the Pacific Northwest are Jonathan and Grimes. Will it be possible by starting with the apple breeding material here mentioned to develop varieties of late keeping winter apples which will be reliably hardy as far north, say, as southern Minnesota, be reliable croppers, and of as high rating in size, form, color and quality as are Gromes and Jonathan?

Evidently this is a long time proposition, and one which is beyond the means of private individuals. To produce a generation of apple trees in this climate, bring them to bearing maturity, and test them sufficiently under orchard conditions to be able to come to fairly reliable conclusions as to their characters of hardiness, productiveness, habit of growth, season of ripening, color, style and quality of fruit, will require from 10 to 15 years at least. Few workers can be expected to carry such work under their personal supervision farther than the F_3 or F_4 generation. Again we remark that only by establishing such work as projects of state or federal institutions, with proper equipment and finanical support, can this kind of work be put upon that stable kind of basis which is essential to substantial and satisfactory scientific progress.

It should be remembered that the apple breeding material with which this work has had to be started does not represent line breeding. It is of mongrel parentage, representing the free intercrossing by winds and insects through all its ancestral lines. Out of something more than 700 varieties which I listed in the "Apples of New York," only a very small percentage are of known seed parentage, and with but very few are both parents known.

In order to begin to lay a foundation for scientific apple breeding, it has been necessary for the workers in this field of efforts first to develop F_1 material of which the parentage on both sides is known, and second to become sufficiently well acquainted with this material to get some understanding of how best to proceed in breeding second or third generation material, and withal to endeavor to make some real contribution to scientific knowledge of the genetic factors or unit characters involved.

We are reminded here of the words of Mendel. After he referred the previous work in plant hybridization and noted that up

to the time when he began his epoch-making investigations, not one of these lines of experiment had "been carried out to such an extent and in such a way as to permit of the possibility of determining:

(1) The number of different forms under which the offspring of hybrids appear,

(2) Or so that these forms may be arranged with certainty according to their separate generations,

(3) Or that their mutual numerical relations can be definitely ascertained."

Mendel then remarked: "It requires indeed some courage to undertake a labor of such farreaching extent." It appears, however, to be the only right way by which we can reach the solution of a question the importance of which cannot be overestimated in connection with the history of the evolution of organic forms.

In like manner it may well be said of the proposition to undertake the breeding of hardy, well colored, late winter apples of high quality for this region, or any considerable portion of it. "It requires indeed some courage to undertake a labor of such farreaching extent." It appears, however, that the only right way by which we can finally achieve the high standards mentioned, is by first laying a foundation by developing suitable material of known line breeding, that can be depended on to transmit to its progeny certain characters. Only then shall we be in position by cross breeding, close in-breeding and segregation and recombination of characters, to make the most rapid and sure progress towards the accomplishment of the project.

What has been said of the natural obstacles to apple breeding in this region applies in a more or less general way to other lines of fruit breeding.

It is gratifying to note that real progress is being made in fruit breeding which is of practical value to the domestic, the amateur, and the commercial fruit grower in this region. In course of time the region will surely produce a much larger proportion than it now does of the fruits and fruit products which it consumes. There appears to be, therefore, for the Upper Mississippi basin, and the Great Plains to the northward, a great future in fruit growing, both amateur and commercial.

The path of progress in this line of human achievement is beset with great obstacles, as we shall see later. In helping to overcome these obtsacles, horticultural science can render great service, a service which will tend to promote the welfare and happiness of millions of people, diversify the industry, and add to the wealth and efficiency of this generation and of succeeding generations for ages to come, and thus contribute in a very definite way to the prosperity and welfare of mankind in this part of the world.

All of this work has this very important significance, namely, that it is making definite contributions to the adaptation of desirable varieties for the pomological interests and industries. This

tends to stabilize fruit growing of this region, enlarge its importance, diversify the wealth producing resources of the people, and advance their welfare and prosperity. It is gratifying to know that a very large part of this work which is now in progress is being done by or under the direction of men who are members of the American Society for Horticultural Science. It is a line of work which is worthy of our hearty support and best efforts.

A Preliminary Report on Apple and Pear Breeding in Maryland

By E. C. AUCHTER, *University of Maryland, College Park, Md.*

INVESTIGATIONS in pear breeding were started in Maryland in 1905 by Hutt and Shaw. This work was continued in 1906 by Ballard. In 1907 Close and Ballard greatly enlarged the scope of the problem and made a large number of crosses, especially between early varieties of apples. Upon the resignation of Close in 1911, Ballard was in charge of the project until 1918, when he became engaged in extension work. The present writer has had charge of the work since that time.

In starting the work with pear breeding it was hoped to secure new varieties in which would be combined productiveness and blight resistance with good quality. Many of our named varieties, although of excellent quality are very subject to fire blight *(Bacillus amylovorus)*. Other varieties such as the Kieffer and similar hybrids, have the reputation of being fairly resistant to blight and heavy producers. Accordingly crosses between the Kieffer and some of our common high quality varieties were made.

The main purpose of starting the apple breeding investigations was to secure if possible a better early apple. Early apple growing on a commercial scale has been very profitable in the middle and southern Atlantic states for several years. It was hoped to secure an apple with red color as early or earlier than the Yellow Transparent, and one which not only would stand up better in shipping, but which would have a little better flavor, as good cooking qualities, and one which would have longer keeping qualities. In addition to this pomological reason of securing a better apple, it was hoped that the study would throw some light on the hereditary transmission of characters in apples and thus be of some value from a purely genetic standpoint.

During the last few years, however, the breeding work with apples has not been limited to early apples alone, but crosses between early and late varieties, and between different late varieties, have been made. As shown by Hedrick, the parents of very few of our apple varieties are known and the great need of careful apple breeding is apparent.

Summary of Apple and Pear Crosses with the Resulting Seedlings

Briefly, the apple and pear crosses which have been made in Maryland during the past fourteen years with the resulting seedlings now growing on the grounds are as follows:

Pear Crosses and Seedlings

Year	Cross	Number of Seedlings	Total For Year
1905	Seckel X Kieffer	6	
	Kieffer X Early Harvest	2	
	Kieffer X Howell	3	
	Kieffer X Seckel	42	53
1906	Seckel X Bartlett	1	
	Seckel X Kieffer	1	2
1907	Kieffer X Seckel	7	
	Seckel X Kieffer	1	8
1908	Kieffer X Angouleme	156	
	Kieffer X Seckel	68	
	Seckel X Kieffer	232	
	Keiffer X Anjou	6	
	Seckel X Anjou	9	471
1909	Kieffer X Angouleme	1	
	Angouleme X Kieffer	1	2
1910	Seckel X Kieffer	708 fruits	0
1911	Seckel X Kieffer	*706 seeds	0
1912	Anjou X Kieffer	3	
	Kieffer X Angouleme	203	
	Seckel X Anjou	101	
	Kieffer X Anjou	227	534
1913	Seckel X Angouleme	42	
	Anjou X Angouleme	5	
	Manning X Angouleme	4	
	Lawrence X Anjou	2	
	Manning X Bartlett	72	125
1914	Anjou X Kieffer	3	3
1915	No crosses made		
1916	Seckel X Anjou	145	145
1917	†Bartlett X Kieffer	2	
	Vermont Beauty X Bartlett	23	25
	Total		1368

Apple Crosses and Seedlings

Year	Cross	Number of Seedlings	Total For Year
1906	Yellow Transparent X Ben Davis	15	
	Yellow Transparent X Williams	15	
	Yellow Transparent X Early Ripe	71	101

*Seeds did not germinate.

†After 1917 it was decided to wait until several seedlings had fruited and some data were obtained in order to find out if possible which crosses to concentrate on in the future in order to obtain the desired results.

Year	Cross	Number of Seedlings	Total For Year
1907	Yellow Transparent X Early Ripe	44	
	Yellow Transparent X Williams	127	
	Yellow Transparent X Red Astrachan	18	
	Yellow Transparent X Red June	46	
	Williams X Yellow Transparent	83	
	Williams X Early Ripe	58	
	Early Ripe X Red Astrachan	10	
	Early Ripe X Yellow Transparent	16	
	Early Ripe X Stayman Winesap	1	
	Yellow Transparent X Nickajack	22	
	Grimes X Red June	2	
	Stayman Winesap X Nickajack	1	428
	Yellow Transparent open	148	
	Williams open	89	
	Early Ripe open	9	246
1908	Early Ripe X Yellow Transparent	8	
	Early Harvest X Williams	1	
	Red June X Williams	1	10
1909	Early Ripe X Yellow Transparent	10	
	Early Ripe X Early Harvest	25	
	Early Ripe X Williams	17	
	Red June X Early Ripe	9	
	Early Harvest X Williams	5	
	Red June X Yellow Transparent	2	
	Early Ripe X Red June	1	
	Red June X Yellow Transparent	8	77
1910	Early Ripe X Yellow Transparent	6 fruits, no seedlings	
	Early Ripe X Early Harvest	25 fruits, no seedlings	
	Red June X Early Ripe	5 fruits, no seedlings	
	Red June X Yellow Transparent	97 fruits, no seedlings	
	Early Ripe X Red June	19 fruits, no seedlings	
	Red June X Early Harvest	92 fruits, no seedlings	
	Early Harvest X Red June	2 fruits, no seedlings	
	Early Harvest X Early Ripe	2 fruits, no seedlings	
	Red June X Williams	9 fruits, no seedlings	
	Early Harvest X Yellow Transparent	1 fruit, no seedlings	
	Stayman Winesap X Nickajack	52 fruits, no seedlings	
1911	Early Ripe X Yellow Transparent	§460 seeds, no seedlings	
	Red June X Yellow Transparent	352 seeds, no seedlings	
	Yellow Transparent X Early Ripe	869 seeds, no seedlings	
	Stayman Winesap X Nickajack	227 seeds, no seedlings	
	Stayman Winesap X Williams	65 seeds, no seedlings	
1912	Grimes X Early Ripe	4	
	Stayman Winesap X Early Ripe	1	
	Grimes X Akin	22	
	Stayman Winesap X Delicious	4	
	Grimes X Stayman Winesap	1	
	Bloomfield X Delicious	19	
	Bloomfield X Oldenburg	12	
	Mother X Bonum	8	
	Yellow Transparent X Oliver	13	
	Wolfe River X Yellow Transparent	19	103
1913	Ingram X Rome	‡6	6
1914	Grimes X Stayman Winesap	3	3

§Seeds did not germinate this year.

‡Poor set of fruit in all other crosses and poor germination of seed.

Year	Cross	Number of Seedlings	Total For Year
1915	**Gravenstein X Doucin**	5	
	Grimes X Stayman Winesap	29	
	Stayman Winesap X Grimes	12	
	Mother X Stayman Winesap	1	47
1916	Mother X Grimes	48	
	Grimes X Stayman Winesap	2	50
1917	‖Stayman Winesap X Grimes	2	2
	Total		1073

‖After 1917 it was decided to wait until several seedlings had fruited and some data were obtained in order to find out if possible, which crosses to concentrate on in the future to obtain the desired results. Accordingly the main emphasis was placed on pollination studies rather than upon seedling production.

It will be noticed that in certain years very few seedlings were secured. Any one, who has done much pollination work, realizes how this might happen. In certain years, due to unfavorable weather conditions, it often happens that practically no set is secured. In other years, frosts destroy the blossoms and occasionally a freeze will destroy the young fruit set. After crossed fruit is obtained, there is always the possibility of a poor germination and finally a big mortality of germinated seedlings until finally planted in the permanent testing grounds. Then, too, when the investigators have several other problems demanding their attention, it can be seen that under such conditions, less work can be accomplished on any one problem than might be done in some institutions, where possibly one man spends all of his time on breeding work. It is useless to explain to this audience that whatever work is done in such problems must, under most conditions, be done in a very few days out of the year.

Methods Used in Securing Seedlings'

Briefly the methods used in securing seedlings up to the time of planting the seed has been similar to that used by practically all investigators in apple pollination. The blossoms of the variety used as the female parent are emasculated and pollinated immediately with previously ripened pollen of the male variety. The crossed bloom is bagged with a Manila sack for a few days and if it is found that some fruit has set, this is then bagged with a mosquito bar bag. At picking time, the seeds are removed and stored.

The general method of securing seedlings at Maryland was as follows: The apple seeds were planted in a light, well drained soil, either in thumb pots or in flats early in the fall and these were then placed in an open cold frame. Great care must be exercised to keep the labels and seeds straight. In March, the seeds were brought into the greenhouse and given gentle heat. Under such conditions the seeds germinated readily. Those in flats were pricked out into small pots after the first two or three leaves appeared, and about the middle of May these seedlings were planted in the testing ground about 2½ feet x 8 feet. In some years, the seeds were planted in a nursery row for 2 or 3 years before plac-

ing in the permanent testing ground, but this was the exception rather than the rule.

Care should be taken not have the greenhouse in which the seedlings are growing too warm, and likewise great care in watering should be exercised if loss from damping off is to be prevented. Slugs of all kinds seem to enjoy the young seedlings and these should be especially guarded against.

In our work, it has seemed rather hard to adopt any reliable system of culling out the undesirable seedlings before the fruiting period. The striking thing noted is the large percentage of good smooth normal trees resulting in the seedlings. Very few indeed were the small, thorny and scraggly appearing trees, which we have been prone to believe was the appearance of all seedling trees. It has often been noted that a tree which started with rather a poor appearance, and downward growing branches for the first two or three years, gradually overcame this peculiarity and assumed a normal aspect as it got older. As a result, we would advise against too heavy or drastic culling in the first three or four years.

Inasmuch as it is desirable to obtain fruit of the cross as soon as possible, the less pruning done the better. Since the first fruits are often borne on the terminals, certainly, heading back of the. branches should be reduced to the minimum. Girdling, by the removal of a narrow strip of bark from the trunk about June 1st will hasten the bearing of five or six-year-old seedlings. In our work just as good results were secured by using a small wire twisted tightly about the trunk. No open wound is left by this means and thus danger from wooly aphis, blight, etc., is reduced to the minimum.

We have made the mistake of leaving our apple seedlings too close together. As a result, they have not grown as rapidly as they should nor have they come into bearing as soon as might be expected. Undesirable seedlings should either be cut out as soon as they have fruited or seedlings should be planted 8x10 feet or 10x10 feet if it is desired to allow them to attain their normal shape. This, of course requires a great deal of ground if large numbers of seedlings are grown and soon becomes a problem.

The grafting of seedlings into mature trees has not been very successful in Maryland, and of course a poorer idea of the tree characteristics of the seedling will be secured by this procedure. It is a hard matter to keep the record straight, especially when several grafts of different seedlings are worked on the same trees. likewise pruning becomes very difficult in such cases.

After records have been secured on tree and fruit and certain seedlings are marked as promising, trees from such individuals should then be propagated and these trees fruited before passing final judgment.

Results of Pear Breeding

Inasmuch as it has been our experience that pear seedlings do not come into fruit as early as the apple seedlings, and since as a result but few of our seedlings have fruited, any further report of

results obtained, other than that previously given will be reserved for a later report.

Results of Apple Breeding

Since many of the apple seedlings have of course not had time to come into bearing, this report must of necessity be considered only as a progress report. More seedlings have fruited from the 1907 crosses than from any other and since these were all early apple crosses, it was decided to limit this part of the report to the results obtained from a study of those seedlings, which have fruited from the early apple crosses in 1907. In this report, only the practical pomological results will receive much attention as it would hardly be worth while or advisable to attempt to study the data from a detailed genetic standpoint at this time since so many of the seedlings have not as yet fruited. Any such data obtained might be found to be wrong at a future date, when greater numbers of seedlings have been studied and thus more harm than good would be done by attempting to analyze such data at this time. At the best, there will not be any too many seedlings to attempt such a discussion in the future when they have all fruited and at that time with greater numbers such studies should be more reliable.

This report, then, gives the data resulting from a study of the fruit of 166 individual seedlings from the early apple crosses in 1907. There are still 259 similar seedlings to fruit from the crosses of this one year. Similar seedlings resulting from crosses made in other years should gradually come into fruit. These data are presented at this time with the hope that our results, including our failures and errors, may be of some little value to any who are just planning to start work along this line. Then, too, the fact that we have so little published data in this field in pomology at the present time, appears to the writer, proper justification for making this preliminary report. If this report encourages others to attempt similar much-needed and extremely interesting investigations, it will be felt that this fact alone has made the paper worth while.

The 1907 Early Apple Crosses

Simply as a matter of general interest, Table I, giving the history of the 1907 early apple crosses from the time of pollination up to the present report, has been prepared. It is of general interest to see what proportion of the various crosses set fruit, how many good and bad seeds were produced, what percentage of the seeds germinated and finally how many of the resulting seedlings are living at this time. It shows what our success has been with the different crosses, what percentage of germination we had and the number of seedlings which we have been able to grow up to this time. It may give some one, who is planning to start such work, an idea of what to expect or, due to our possible poor results, it may spur him on with the determination to avoid the mis-

TABLE NO. 1

THE HISTORY OF THE 1907 EARLY APPLE CROSSES FROM TIME OF POLLINATION IN 1907 TO THE PRESENT REPORT IN 1920

CROSS	Number Buds Emasculated and Pollinated	Number fruits Set On May 20th	Number fruits Set On June 25th	Number Fruits Ripened and Picked	NUMBER OF SEEDS Plump	Thin	Abortive	Total	Number Planted	Number Germinated and Put in Nursery Row	Number Seedlings Transplanted	Number Fruited At This Date	Number Dead	Number Living Unfruited
Early Ripe X Yellow Transparent	126	12	12	12	37	1	11	49	40	19	17	13	1	3
Early Ripe X Red Astrachan	124	3	3	3	14	0	2	16	14	10	10	3	0	7
Early Ripe X Williams	155	1	1	1	5	0	0	5	5	0	0	0	0	0
Early Ripe X Stayman Winesap .	285	8	7	5	12	2	6	20	12	2	2	0	1	1
Yellow Transparent X Red Astrachan	106	36	31	31	91	7	40	138	79	27	24	2	6	16
Yellow Transparent X Eary Ripe	187	71	51	51	164	18	53	235	162	52	45	19	1	25
Yellow Transparent X Nickajack	98	33	26	26	68	8	23	99	64	23	22	0	0	22
Yellow Transparent X Williams	475	206	138	138	365	57	98	520	374	141	133	29	6	98
Yellow Transparent X Red June	60	26	23	23	61	17	19	97	61	56	56	14	10	32
Williams X Early Ripe	244	43	27	21	134	8	24	166	69	64	64	35	0	23
William X Yellow Transparent	180	24	23	23	160	7	15	182	162	99	86	51	3	32
Total	2940	463	342	334	1111	125	291	1527	1042	493	459	166	34	259
Williams open ..	....	......	......	32	252	7	15	274	314	93	93	31	4	58
Yellow Transparent open	....	......	......	180	881	20	51	952	562	172	166	55	18	93
Early Ripe open	....	......	......	18	90	3	5	98	40	10	9	4	0	5
Total				230	1223	30	71	1324	916	275	268	90	22	156

takes, which have been mentioned previously and to obtain better results from the time of pollination to the bearing seedling 14 years later.

It can be seen that certain crosses set fruit better than others, that more seeds per apple were produced from some crosses, that the percentage of seeds germinated varied considerably, and finally that a greater percentage of seedlings, whether from poor environmental conditions or weak constitutional vigor, died from certain crosses than others.

Summarizing the table, it is seen that from a total of 2940 buds which were emasculated and pollinated in the various crosses, 334 fruits or 11.36 per cent were obtained. These 334 fruits produced a total of 1527 seeds or an average of 4.57 per fruit. Of this number 1042 seeds were planted of which number 493 or 47.31 per cent germinated and were planted in the nursery row. Of the 493 germinated seedlings, 459 or 93.10 per cent lived and were planted in the permanent testing grounds two years later. Of the 459, there are now 425 or 92.6 per cent living and 34 or 7.4 per cent dead. Thus of 1042 seeds planted we have 425 trees or 40.78 per cent now living, or of 493 germinated seeds we have 425 trees or 86.2 per cent living. This leaves 13.8 per cent which have succumbed during the 14 years for various reasons.

Seeds were taken from open pollinated fruits of Yellow Transparent, Williams, and Early Ripe, during this same year. Of 230 fruits, 1324 seeds or an average of 5.76 seeds per fruit were obtained. Of these seeds, 916 were planted and 275 or 30 per cent germinated. In the nursery row 268 lived and were finally planted in the permanent testing ground. Of these 268, 90 or 33.5 per cent have fruited, 156 or 58.2 per cent have not fruited, and 22 or 8.3 per cent have died.

The Fruit Descriptions of the 1907 Crosses

We now come to a study of the fruit from these several crosses. In each case, the fruit from each seedling was described carefully, both externally and internally, according to the usual systematic descriptions. In this report, only certain characters such as form, size, color, flavor, and date of ripening are presented. The fruits from each cross were placed in the divisions under which they fell and a summary of the results are shown in Table II.

Before discussing these results, it might pay to give a brief description of the same characters for each of the parents, as given for the seedlings.

In Maryland, the Early Ripe is a greenish yellow variety, oblate in shape, but sometimes slightly inclined to conic. In general, it is medium or above medium in size being about 2.75 inches in width and 2 inches in length. It is a mild, sub-acid apple and ripens from July 1st to 6th.

The Early Harvest is a yellow apple, oblate in shape, but slightly inclined to conic. It is below medium to medium in size being about 2.4 inches in width and 2 inches in length. It is at

TABLE II

THE DISTRIBUTION OF THE FRUIT OF THE 1907 EARLY APPLE CROSSES AS TO FORM, SIZE, COLOR, FLAVOR AND DATE OF RIPENING

Number of Each Cross	35		14		29		51		19		13		3		2		31		55		4	
CROSS	W. x E. R.		Y. T. x R. J.		Y. T. x W.		W. x Y. T.		Y. T. x E. R.		E. R. x Y. T.		E. R. x R. A.		Y. T. x R. A.		W. Open		Y. T. Open		E. R. Open	
FORM	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent
Round	3	8.58	2	14.28	0	0.00	4	7.84	2	10.52	0	0.00	0	0.00	0	0	2	6.45	4	7.27	2	50
Roundish-Conic	14	40.04	5	35.70	17	58.62	24	47.05	10	52.60	3	23.10	0	0.00	0	0	8	25.80	13	23.63	1	25
Roundish Truncate	0	0.00	1	7.14	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0	3	9.67	0	0.00	0	0
Roundish-Conic-to Truncate	0	0.00	0	0.00	0	0.00	2	3.92	0	0.00	0	0.00	0	0.00	0	0	0	0.00	0	0.00	0	0
Roundish-Oblong	1	2.86	0	0.00	0	0.00	0	0.00	1	5.26	0	0.00	0	0.00	0	0	4	12.90	0	0.00	0	0
Oblong-Conic	0	0.00	0	0.00	1	3.44	1	1.96	2	10.52	0	0.00	0	0.00	0	0	0	0.00	0	0.00	0	0
Roundish-Oblate	8	22.88	3	21.42	0	0.00	5	9.80	1	5.26	5	38.50	1	33.33	0	0	10	32.26	13	23.13	1	25
Roundish-Oblate-incl. to Conic	2	5.72	0	0.00	0	0.00	0	0.00	2	10.52	2	15.40	0	0.00	0	0	0	0.00	4	7.27	0	0
Oblate-Conic	6	17.16	0	0.00	2	6.88	5	9.80	0	0.00	1	7.70	0	0.00	0	0	0	0.00	3	5.45	0	0
Oblate	1	2.86	3	21.42	9	31.05	10	19.60	1	5.26	2	15.40	2	66.66	2	100	4	12.90	18	32.70	0	0
SIZE IN INCHES																						
Very Small 0 "-2 "	0	0.00	0	0.00	0	0.00	4	7.84	1	5.26	0	0.00	0	0.00	0	0	1	3.22	3	5.45	0	0
Small 2 "-2¼"	4	11.14	2	14.28	4	13.76	8	15.68	6	31.56	2	15.40	0	0.00	0	0	5	16.13	14	25.45	2	50
Medium 2¼"-2½"	15	42.90	9	64.26	20	69.00	22	43.14	8	42.08	6	46.20	1	33.33	2	100	9	29.08	19	34.50	1	25
Medium to Large 2½"-2¾"	11	31.46	2	14.28	4	13.76	11	21 57	2	10.52	4	30.80	2	66.66	0	0	10	32.26	10	18.18	1	25
Large 2¾"-3 "	5	14.30	0	0.00	1	3.44	5	9.80	1	5.26	1	7.70	0	0.00	0	0	6	19.35	6	10.90	0	0
Very Large 3 "+	0	0.00	1	7.14	0	0.00	1	1.96	1	5.26	0	0.00	0	0.00	0	0	0	0.00	3	5.45	0	0
COLOR																						
Yellow	6	17.16	9	64.26	11	37.93	19	37.25	17	89.47	13	100.00	2	66.66	2	100	4	12.90	20	36.36	2	50
Yellow-Blush	3	8.58	4	28.56	0	0.00	3	5.88	0	0.00	0	0.00	0	0.00	0	0	10	32.26	14	25.45	1	25
Yellow-Gray Overcast	0	0.00	0	0.00	0	0.00	1	1.96	0	0.00	0	0.00	0	0.00	0	0	0	0.00	0	0.00	0	0
Yellow-Striped, Red or Carmine	9	25.74	0	0.00	12	41.37	12	23.53	1	5.26	0	0.00	0	0.00	0	0	4	12.90	8	14.54	0	0
Yellow-Splashed and Striped	7	20.02	0	0.00	2	6.88	4	7.84	0	0.00	0	0.00	0	0.00	0	0	0	0.00	4	7.27	0	0
Yellow-Mottled and Striped	8	22.88	0	0.00	3	10.32	6	11.76	0	0.00	0	0.00	1	33.33	0	0	7	22.58	5	9.09	1	25
Yellow-Mottled and Splashed	0	0.00	0	0.00	0	0.00	3	5.88	0	0.00	0	0.00	0	0.00	0	0	1	3.22	0	0.00	0	0
Yellow-Mottled and Washed	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0	2	6.45	1	1.81	0	0
Yellow-Splashed and Streaked	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0	3	9.67	0	0.00	0	0
Yellow-Mottled, Washed and Striped	2	5.72	0	0.00	0	0.00	0	0.00	0	0 00	0	0.00	0	0.00	0	0	0	0.00	2	3.62	0	0
Red	0	0.00	1	7.14	0	0.00	3	5.88	1	5.26	0	0.00	0	0.00	0	0	0	0.00	1	1.81	0	0
FLAVOR																						
Acid	2	5.72	6	42.84	13	44.81	3	5.88	4	21.04	0	0	0	0	2	100	1	3.22	4	7.27	0	0
Sub-Acid	16	45.76	2	14.28	9	31.05	25	49.02	8	42.08	4	30.80	3	100.00	0	0	13	41.93	25	45.45	2	50
Mild Sub-Acid	9	25.74	3	21.42	5	17.20	17	33.33	2	10.52	5	38.50	0	0	0	0	13	41.93	13	23.63	2	50
Nearly Sweet	7	20.02	2	14.28	0	0.00	3	5.88	2	10.52	4	30.80	0	0	0	0	2	6.45	11	19.99	0	0
Sweet	1	2.86	1	7.14	2	6.88	3	5.88	3	15.78	0	0.00	0	0	0	0	2	6.45	2	3.62	0	0
DATE OF RIPENING																						
July 1-5							v															
July 6-15	-v		-v						-v		v		v								v	
July 16-28					v						-v		-v		-v		v		v			
July 29-Aug. 15	-v		-v		-v		-v		-v						-v						-v	
Aug. 15-Sept. 15																	v		-v			

W.=Williams. E. R.-Early Ripe. Y. T.-Yellow Transparent. R. J. Red June.
R. A.—Red Astrachan.

first brisk sub-acid but gradually becomes sub-acid as it ripens. Its ripening period extends normally from July 10th to July 20th.

The Yellow Transparent is a yellow apple varying from roundish oblate to oblate conic. It is about medium or slightly above medium in size being about 2.5 inches in width and 2.25 inches in length. It is acid to sub-acid in flavor and ripens from July 10th to July 25th in normal seasons.

The Red June has a pale green undercolor, generally completely overspread with a dark red over color. It is roundish ovate to roundish oblate and generally medium to above medium in size, being about 2.3 inches wide and 2.3 to 2.4 inches long. It is a mild sub-acid apple, which ripens from July 10th to July 23rd.

The Red Astrachan has a yellowish undercolor, variously striped and washed with light and dark red over color. It is roundish to roundish oblate and generally medium to above medium in size, being about 2.75 inches in width and 2.2 inches in length. It is acid to brisk sub-acid in flavor and ripens from July 10th to July 26th.

The Williams has a yellow undercolor, completely overspread with a deep red over color. It is indistinctly striped with dark red carmine stripes. In shape, it is roundish conic to oblong conic and is above medium in size being about 2.8 inches in width and 2.7 inches in length. It is very mild sub-acid and ripens from July 30th to August 10th.

Table II shows the distribution of the fruit of the various seedlings as to size, form, color, flavor and date of ripening. Although in several cases, the numbers involved are too few to give any indication of how the offspring of such crosses might be expected to appear, still in other cases, enough seedlings are considered to give some idea of what to expect in such crosses.

Shape and Length of Seedling Fruit and Prepotency of Parents

It has been stated by some investigators that the female parent is more prepotent or transmits more of its characters to the offspring than the male. Likewise, the reverse has been stated. A study of these crosses would suggest, for the varieties studied at this time, that it was not so much a matter of either parent transmitting most of its characters, but that rather certain factors or characters in certain varieties were the dominant ones and were transmitted regardless of which parent the certain variety happened to be. For instance, in the case of Yellow Transparent X Williams, 18 or nearly two-thirds of the seedlings are roundish conic to oblong conic similar to the Williams, which in this case was the male parent. In the reciprocal cross Williams X Yellow Transparent, 31 or nearly two-thirds of the seedlings again tend to be roundish conic or oblong conic similar to the Williams, which in this case was the female parent. The Williams has the appearance of being and is a longer apple than the Yellow Transparent. These results suggest that the factor or factors carrying the longer lengths, thus producing apples which appear long, is dominant

over that factor or factors carrying the shorter lengths, thus producing apples more oblate in appearance and that this is of more importance than the fact of whether a variety is the male or female parent. This condition is again seen in the cross Yellow Transparent X Early Ripe and in the reciprocal, Early Ripe X Yellow Transparent. In these crosses, the Yellow Transparent appears to be and is a longer apple than the Early Ripe. A higher percentage of the resulting seedlings again fall in the longer group, regardless of whether the Yellow Transparent is the male or female parent. In the case of the Williams X Early Ripe cross a higher percentage of the seedlings again fall in the longer group, as do those of the Red June X Red Astrachan cross. It might be suggested that the Williams was more dominant in transmitting its shape than the Yellow Transparent in the two crosses, that Yellow Transparent in turn was more dominant in transmitting its shape over Early Ripe in the two crosses, that Williams was more dominant in transmitting its shape over Early Ripe, and that the Red June was more dominant in transmitting its shape than the Red Astrachan. And while this may be true, still it is more strongly suggested, as stated above, that the factor or factors which carry greater length are more dominant over those which carry shorter length, and as a result, we might expect to get a higher percentage of seedlings which would appear like the longer parent, regardless of which parent or variety it happened to be. Of course these findings may not be substantiated when more seedlings come into fruit.

Size of Seedling Fruit

Since so many different environmental factors may enter in to affect size, and since the most of the parents worked with were so similar in size, no attempt to analyze these data further than the distribution shown in Table II will be made at this time.

Color of Seedling Fruit

Table II gives the color of the seedling fruits resulting from the different crosses. No attempt at this time will be made to study each variety critically, but in general it can be seen that the factor or factors which carry color (red, pink or carmine) are dominant over the factor or factors carrying yellow. In this case again the fact that red color seems to be dominant, appears to be more important and significant than the question of whether the male or female parent is the more prepotent in this respect. A higher percentage of the offspring carry red color in them, regardless of whether the red parent is male or female. This is brought out in the reciprocal cross, Yellow Transparent X Williams, and in the single cross Williams X Early Ripe. Whether this condition will continue to exist when more seedlings have fruited remains to be seen.

It is of interest to note that one red striped apple and one solid red apple out of ninteen seedlings were secured from the cross of two yellow parents, Yellow Transparent X Early Ripe.

This would tend to indicate that one or both of the yellow apples are heterozygous for color. Color itself may be due to a number of factors, such as a factor for pigment and a factor for a specific shade of color as shown by Emerson in the case of beans. In these two hybrids there may have been brought together this pigment and a color factor. Until color in apples is more clearly understood, any explanation for this occurrence is purely theoretical. It will be of interest to see if other colored apples appear from this and its reciprocal cross, when the remaining seedlings come into fruit.

Flavor of the Seedling Apples

Although no sweet apples were used in any of these crosses, still several seedlings having sweet fruit showed up in several of the crosses. These are not very numerous, however, and probably the factors carrying sweetness are recessive. In nearly every case, there are higher percentages of acid to sub-acid fruits than there are of mild sub-acid or nearly sweet. This holds again regardless of which parent is the male or female and suggests that the factor or factors which carry acid or sub-acid flavor, are dominated over those carrying mild sub-acid or nearly sweet flavor.

Date of Ripening of Seedlings

Date of ripening is evidently an inherited character as the seedlings resulting from these early apple crosses all ripened early. The range of the ripening period did not extend over two weeks on either side of the ripening period of the parents and, in general, most of the seedlings of a certain cross ripened during the same period as the parents.

The F_1 Generation

It is hardly necessary to draw attention to the fact that most of our present apple varieties are hybrids or in reality F_1 generation. Thus when these are crossed, the resulting seedlings are really an F_1 generation of hybrids and would break up in a similar manner to an F_2 generation for the characters studied.

Open-Pollinated Seedlings

Seedlings from open-pollinated fruits of three early varieties were planted and gave fruits as shown in Table II.

Promising Seedlings Obtained from Crosses

From a pomological standpoint and the practical growers' viewpoint, the most important part of the investigations is whether any seedlings have been secured which are considered worthy of propagation. Have any seedlings been produced up to this time which fill the requirements of the object of the investigations, namely an apple of good cooking, dessert and shipping qualities, as early as the Yellow Transparent and with red color? Following are the results:

In the cross Yellow Transparent X Williams, out of 29 seedlings, 6 are marked as very promising, and 3 for further testing.

Of the cross Yellow Transparent X Red June, out of 14 seedlings, 2 are marked as very promising.

Of the cross Williams X Early Ripe, out of 35 seedlings, 4 are marked as very promising, and 3 for further testing.

Of the cross Williams X Yellow Transparent, out of 51 seedlings, 10 are marked as very promising, and 5 for further testing.

Among the seedlings of this last cross, one was found which ripened on July 10th as early as the earliest of the Yellow Transparents. The fruit was roundish oblate, between 2¾ and 3 inches in diameter. The flavor was a good, mild sub-acid, and the color was pale yellow beautifully striped and splashed with a pink to red color.

Of the two seedlings from the Yellow Transparent X Red Astrachan cross and the three seedlings from the Early Ripe and Red Astrachan cross, none were promising or saved for further testing.

Of the crosses in which both parents were yellow, one seedling out of 13 of the Early Ripe X Yellow Transparent cross was marked as very promising.

Of the Yellow Transparent X Early Ripe cross, out of 19 seedlings one was marked as very promising.

In both of the above cases, the seedlings were yellow and were saved because of their size and good quality.

It appears from these results that when either Yellow Transparent, Early Ripe, Red June, or Williams, are intercrossed in large enough numbers, some desirable seedlings should result. Williams especially is a good variety to use in early apple breeding.

Thus of the 166 crossed seedlings, 24 appear to be very promising and in addition eight are held for further testing.

Although several of these may be culled out later, still such results make the outlook very bright for improving apple varieties by cross breeding.

Results from Open-pollinated Seedlings

Seeds from open-pollinated fruits of Early Ripe, Williams, and Yellow Transparent, were planted in 1907. Near the Early Ripe tree were growing such varieties as Shockley, Smokehouse, Kinnard, Jonathan Buler, Lawver, etc. Near the Yellow Transparent were Chenango, Red Astrachan, Bailey Sweet, Bonum, Red June, etc. Near the Williams tree were Nickajack, Stayman Winesap, Arkansas, etc.

Of 31 open pollinated Williams seedlings, one was marked as promising.

Of 55 open pollinated Yellow Transparent seedlings, one was marked as promising.

Of 4 open pollinated Early Ripe seedlings, none was marked as promising. Thus of 90 open pollinated seedlings of these varieties, only two were marked as promising.

This suggests that a greater percentage of desirable seedlings

will result from careful cross breeding of desirable parents. Good seedlings can be secured no doubt from the seeds of open-pollinated fruit, but the chances are that much larger numbers of seedlings must be grown in order to get the same number of promising new varieties. This may be the more desirable method, however, in certain cases where time for cross breeding is limited and where land is not the limiting factor. But even then after such varieties were established, their paternal parentage would remain unknown.

SUMMARY

1. Pear breeding investigations were started in Maryland in 1905 It was hoped to secure seedlings which would combine productiveness and blight resistance with good quality.

2. Apple breeding investigations were started in 1906. It was hoped to secure a variety as early or earlier than, Yellow Transparent and one which had red color. In addition, better shipping and keeping qualities were desired without the loss, if possible, of cooking or eating quality.

3. A total of 1368 pear seedlings are now growing, some of which have fruited.

4. A total of 1073 apple seedlings are now growing, some of which have fruited.

5. This report gives a detailed account of the early apple crosses made in 1907.

6. A detailed description of certain characters of 166 crossbred apple seedlings and 90 seedlings derived from open-pollinated fruit is given.

7. These findings suggest that in the varieties studied, neither the male nor female parent is the more prepotent in transmiting such factors as form, color, and flavor. It suggests that the factor or factors, which transmit the longer lengths in apples, thus producing longer appearing apples, are dominant over the factor or factors producing shorter lengths and consequently shorter appearing apples. This held with a long conic apple whether it was the paternal or the maternal parent.

8. The factor or factors transmitting red color seemed to be dominant over those transmitting yellow color regardless of which variety was the maternal or the paternal parent.

9. The factor or factors transmitting acid to sub-acid flavor appeared dominant to those transmitting mild sub-acid or nearly sweet flavor.

10. Date of ripening is evidently an inherited character as all seedlings had about the same ripening period as their parents.

11. Of the 166 crossed seedlings, 24 appear to be very promising and in addition 8 are held for further testing. Williams especially, is a good variety to use in early apple breeding.

12. Of 90 seedlings produced from open pollinated fruit only 2 were marked as promising. Thus it appears that much greater numbers of open-pollinated seedlings must be planted in order to secure the same number of desirable seedlings, and then only the maternal parent would be known.

An Experience in Self-Fertilization of the Peach

By C. S. CRANDALL, *University of Illinois, Champaign, Ill.*

IN connection with a schedule of cross-pollinations on seedling peach trees, in 1913, a limited test of self-fertility was undertaken. Fourteen lots of 25 bags each were adjusted over emasculated buds on 13 trees grown from crosses made in 1908. Parentage of the trees was as follows: Ten had Bokhara as the pistillate parent and each a different variety as the pollen parent; one was from the cross Yenshi X Bokhara and two were from different crosses of Triumph X Early Crawford. One of these last carried two lots, or 50 bags, instead of 25, the number alloted to each of the other trees.

At the time of emasculation, unopened buds were collected from each of the trees, taken to the laboratory and the pollen extracted; this pollen was stored in a dry place and, three days later, applied to the stigmas of the flowers of the tree from which it had been taken.

Numbers of emasculations within the different lots ranged from 64 to 92. The total was 1113. Pollinations ranged from 54 to 89 with a total of 1022. This means that 91 emasculated buds were discarded, at time of pollination, because of evident or suspected imperfections.

Fruits reaching full maturity numbered 355, representing 34.73 per cent of the flowers pollinated. One fruit was matured from pollination of each 2.87 flowers. There was no uniformity in fruit returns from the different trees. The smallest return is recorded for the seedling from the cross 128-2 Bokhara X Late Crawford. In this case pollination of 77 flowers gave 9 fruits representing 11.68 per cent of the pollinations. The largest fruit production fell to the seedling from the cross 131 Bokhara X Niagara; here pollination of 70 flowers gave 43 fruits; hence 61.42 per cent of the pollinations were successful.

These percentages, based upon fruit-production, would stand as representing a fair degree of success if fruit-production was all that is desired, but fruit-production is not the ultimate aim. It is desired to breed other generations in an attempt to determine the manner of transmission, the stability and relative worth of tangible parental characters combined in the progeny. To this end it is essential that fruits produced from controlled pollinations contain seeds that are not only viable, but possessed of power to produce vigorous seedlings that will live and, in time, pass their characters on to progeny.

There are four points at which performance of seeds from peach fruits developed from controlled pollinations is checked.

1. Preparatory to planting, pits are cracked; undeveloped

kernels discovered and discarded. Twins also are found and provided for in the scheme of numbering.

2. Germination. Record is made of seedlings appearing above ground.

3. At time of transfer to nursery. Very weak seedlings die in the interval between appearance above ground and removal to nursery.

4. Planting in orchard the following spring. Some seedlings that go to the nursery are weak. They die during the summer, or in storage the following winter.

Seedlings planted in orchard, after one season in nursery, are, as a rule, vigorous individuals that will survive to fruiting age. Rarely is there any loss that can be ascribed to constitutional weakness, after seedlings are planted in orchard.

Performance of seeds from the group of fruits from self-pollinations of 1913 may be briefly given. There were 355 fruits, an equal number of pits. When these pits were cracked, in the spring of 1914, 19 were found with undeveloped kernels; here was a loss of 5.67 per cent at the first checking. There were planted 336 seeds or kernels; the number germinating with sufficient vigor to push the cotyledons above ground was 206, hence there were 130 seeds that either did not germinate at all, or so feebly as to fail to reach the surface and this second checking records a loss of 38.69 per cent of the seeds planted. There were transferred to nursery 202 seedlings; only four died in the interval between appearance above ground and removal to nursery. In the spring of 1915, there were planted in orchard 188 seedlings; this number is less by 14 than the number planted in nursery; hence 14 seedlings died, either during the first summer, or in storage the following winter.

Each of the four times the seeds or seedlings were checked a loss was recorded and in the aggregate this loss amounts to 47 per cent of the fruits matured.

The degree of success for the self-pollinations of this group, as based upon fruit-production, was found to be 34.73 per cent; if, instead, seedlings planted in orchard be accepted as a proper basis from which to measure success, it appears that the success attained was 18.39 per cent.

The percentages computed apply to the aggregate of the 14 lots. Individual lots varied greatly in losses sustained; for one the loss was total. This was one of two lots on the same tree, a seedling of cross 159 Triumph X Early Crawford in which pollination of 89 flowers yielded 17 fruits; of the 17 pits, five were found worthless when cracked and of the 12 apparently normal seeds planted, not one germinated. Performance of the other lot on this tree was, in some degree, better; 72 pollinations gave 37 fruits; seven pits contained no embryos and, of the 30 seeds planted, eleven germinated and seven seedlings lived to be planted in orchard. For this lot the percentage of success, based upon seedlings in orchard, was 9.72, or, if the two lots on this tree be combined, the degree of success was less than 4½ per cent.

The two lots just considered may be compared with the lot on the seedling from cross 105 Bokhara X Yenshi. Here, 79 pollinations gave 42 fruits having 40 apparently good seeds, 31 of which germinated. A year later, 28 vigorous seedlings were planted in the orchard. Based upon fruit production the percentage of success was 53.16; based upon trees planted in orchard 35.44, and this was the maximum percentage for a single lot. Another lot, although ranking ninth in the list of 14, in percentage of fruit-production, was quite satisfactory in subsequent performance. This was from the seedling from cross 65 Bokhara X Oldmixon Cling; 76 flowers pollinated gave 22 fruits; 22 seeds were planted and 21 germinated; every seedling was vigorous, all passed the ordeal of the winter of 1917-18 and all but one bore heavy crops in 1920. Fruits from trees of this group were well above average in size, coloring and quality, and seven of them bore fruits of such excellence that they are retained for breeding purposes and to be propagated for further trial.

In 1914, 185 buds were emasculated and hand-pollinated, and 202 buds were covered without emasculation and left without hand-pollination. From the hand-pollinated group, 82 fruits matured; 81 seeds were planted, but only one seedling appeared above ground. This was from a seedling of cross 75 Bokhara X Strout Early. This seedling grew vigorously, fruited in 1920, and is retained for further observation because of the high quality of the fruit.

The other group of 202 buds not hand-pollinated yielded 75 fruits; 75 seeds were planted and 51 seedlings lived to be planted in orchard. About half of these seedlings were killed by low temperature during the winter of 1917-18; 27 fruited in 1920, but the fruits were so uniformly inferior that all seedlings of the group were discarded.

For the year 1916 no emasculating or pollinating was done, but 1,028 buds were covered. The fruits matured numbered 118 and 116 seeds were planted, but only nine seedlings appeared above ground. Two were from cross 449, Late Crawford X Carman, four from cross 177, Bokhara X Late Crawford, two from cross 182-1, Yenshi X Bokhara and one from cross 22-1, Bokhara X Triumph. Six of these seedlings are living in the orchard; they are vigorous, but have not yet fruited sufficiently to allow an estimate of their fruiting characteristics.

These tests of self-fertility of peach trees in the orchard may be summarized as of two groups.

1. —Buds emasculated and hand-pollinated. Pollinations number 1,207, fruits matured 437 or 36.2 per cent. Twenty, or $4\frac{1}{2}$ per cent of the pits had undeveloped embryos. Seeds planted, 417; germinated, 207, or practically 50 per cent. Seedlings shifted to nursery, 203; planted in orchard 189, representing $15\frac{2}{3}$ per cent of the flowers pollinated, or $43\frac{1}{4}$ per cent of the fruits matured, or 45.32 per cent of the seeds planted. One tree in orchard required pollination of 6.38 flowers.

2. Buds covered, neither emasculated or hand-pollinated.

Buds covered 1,230; fruits matured 193 or 15.68 per cent. Two pits had undeveloped embryos. Seeds planted 191; germinated 61 or nearly 32 per cent. Seedlings to nursery 61, planted in orchard 60, representing 4.88 per cent of the flowers pollinated, or 31.08 per cent of the fruits matured, or 31.41 per cent of the seeds planted. One tree in orchard required the covering of 20½ buds.

Self-pollination of peach flowers under glass has been but little more successful than in the orchard, as far as fruits produced are concerned. The ratio of fruits to flowers for the orchard is one fruit for 3.87 flowers; for the greenhouse, one fruit for 3.33 flowers. But, if degree of success is based upon numbers of seedlings surviving to be planted in orchard, the work in orchard has been far more successful than that done under glass. This result is due to imperfections in development of seeds produced in the greenhouse; either embryos do not develop, or seeds that appear to be normal do not germinate. It is probable that this condition is a result of deficient nutrition due to the restricted feeding ground of trees grown in tubs.

Two methods were employed in the greenhouse. For four of the six years of record all flowers were emasculated and, after an interval, pollinated by hand. For two of the years, 1917-18, buds were covered without emasculation, but all were hand-pollinated. The first group includes the years 1915, 1916, 1919, and 1920, and in these years 1,242 flowers on 23 hybrid seedlings in tubs were emasculated, and, later hand-pollinated, the flowers of each tree with pollen from the same tree.

The fruits matured numbered 357, representing 28¾ per cent of the flowers pollinated. Quality of seeds is known for the three earlier years only. Seeds from fruits of 1920, 135 in number, are now stratified and will not be cracked until planting time in March. The three earlier years include 591 pollinations, maturing 222 fruits, or 37½ per cent of the pollinations successful. There were planted 193 seeds, hence 29 of the fruits or 13.07 per cent contained pits in which no embryos developed. Of the 193 seeds planted only 9 or 4⅔ per cent germinated. The 9 seedlings belong to two of the 12 hybrid seedlings on which flowers were self-pollinated in 1919. Six were from a seedling of the 1911 cross 448, Late Crawford X Carman. Here 39 flowers pollinated yielded 27 fruits containing 28 seeds. The six germinated represent 21.42 per cent of the seeds planted, or 15.36 per cent of the flowers pollinated.

The three remaining seedlings were from a seedling of the second generation cross of 1914, 22-1, Bokhara X Triumph X Bokhara. In this case 27 flowers pollinated gave 19 fruits with 19 seeds, only three of which produced seedlings. Germination here represents 15.79 per cent of the seeds planted, or 11.11 per cent of the flowers pollinated.

For the years 1917-18, 1,364 buds on 20 hybrid seedlings were covered without emasculation and, afterwards, hand-pollinated. The 425 fruits matured represent 31.16 per cent of the flowers pollinated. When the pits were cracked, 177 or 41.64 per cent were

found with undeveloped embryos. This left 248 apparently good seeds which were planted, but only 19 germinated. The seedlings were vigorous and all but one of them found a place in the orchard. Thus, less than 8 per cent of the seeds planted, or about 4½ per cent of the fruits matured, or less than 1½ per cent of the flowers pollinated, were represented by seedlings in the orchard.

Considering the aggregate of greenhouse pollinations with reference to fruit production, there were matured 782 fruits which represent 30 per cent of the 2,606 pollinations made. Seed performance can be given only for the years preceding 1920. In these years, 1,955 pollinations gave 647 fruits which represent 33 per cent of the flowers pollinated. The number of pits found with undeveloped embryos was 206, or nearly 32 per cent of the total. Eliminating these, there remained 441 pits, each of which contained a kernel that, so far as could be determined by inspection, was normal and viable, yet when planted only 28, or less than 6½ per cent germinated.

All but one of the seedlings were planted in the orchard. They represent 1.38 per cent of the flowers pollinated; each seedling in the orchard required the pollination of 72.4 flowers.

Bringing together the self-pollinations of orchard and greenhouse, it appears that 5,043 flowers were included. The 1,412 fruits matured represent 28 per cent of the flowers used. Of the fruits for the years preceding 1920, approximately 18 per cent, mostly from the greenhouse, had undeveloped embryos. Of the 1,049 seeds planted, 296 or 28.21 per cent germinated, and 93¼ per cent of the seedlings were planted in the orchard. The ratio of trees in the orchard to flowers used is approximately 1 to 16.

Grape Varieties That Produce Seedlings of Superior Merit

By RICHARD WELLINGTON, *Experiment Station, Geneva, N. Y.*

ABOUT 11,000 grape seedlings have been grown on the grounds of the New York Agricultural Experiment Station. The exact number can not be given, as there is no definite record of the seedlings grown in the early eighties. However, since a definite system of numbering was started, 10,614 seedlings have been set out in the vineyards. A few of these seedlings have proved to be males, some have died before fruiting, and some have not yet fruited, so the number of seedlings that have fruited is less than 10,614. To produce these seedlings, there were made 371 variety crosses, 38 variety by seedling crosses, 9 seedling by seedling crosses, 163 variety self-fertilizations, 50 seedling self-fertilizations and a few species crosses. The number of plants in each cross or self-fertilization varied from one to over 500.

It was hoped to present a summary of the results obtained from each cross and self-fertilization at this meeting, but time and space prevent such a report. A tabulation has been made, however, of those crosses and self-fertilized varieties which have produced seedlings of sufficient merit to warrant further trial with the object of showing what varieties have made the best parents. Varieites not mentioned in this paper have either not been used as parents or their seedlings have possessed no exceptional merit. Of the 98 seedlings selected for a further test, probably about one in ten will become a desirable variety. Thus out of a population of one thousand, only one individual would be perpetuated. This proportion is too low, but if we benefit from our experience this ratio should be reduced in the future from five to ten times.

Nine selfed varieties or about one-eighteenth of the total varieties selfed, 2 selfed seedlings or one-twenty-fifth of the total selfed seedlings, 34 variety crosses or about one-eleventh of the total variety crosses, 8 crosses between varieties and seedlings or less than one-fifth of such crosses, and one seedling cross or one-ninth of the total seedling crosses, were used in the production of the selected seedlings. It will be noted that the crosses have given proportionately more deisrable seedlings than the selfed varieties. Most of the varieties used have proved to be poor parents, that is, they produce few or not any progeny that rank above the average. A very few varieties on the other hand have produced a remarkably large number of excellent seedlings. This same phenomenon occurred in the case of raspberries, as was reported in the 1913 report of this Society and is found to hold for all the other fruits being bred at this Station. Certain crosses as may be noted in the following table have given one hundred per cent desirable progeny, but in all such cases only one seedling was grown. Undoubtedly if more seedlings had been grown, the percentage would have been lower, for in no case did such a high per cent occur when more than one seedling was grown.

Governor Ross X Mills, Mills X (Winchell X Diamond), Triumph X Mill, and Winchell X Diamond, have proved to be the most desirable crosses. Those crosses which have produced only one desirable seedling may be equally good, but until more extensive tests have been made it is well not to say much about them. The results would be much more outstanding if all the selfed varieties and crosses had been included.

The number of times varieties have been used in the production of the above seedlings are as follows: Once—Brilliant, Champion, Chasselas Besson, Chasselas Rose, Collier, Concord (sport), Croton, Delago, Downing, Dutchess, Empire State, Franken Reisling, Gaertner, Goff No. 19, Hercules, Janesville, King Philip, Lindley, Lutie, Mabel, Merrimac, Niagara, Ozark, Pinot Gris, Rochester, and Standard; twice—Concord (seedless), Delaware, Diana, Goethe, Goff, Grosse Blaue, Salem, Seibel No. 2 and Vergennes; three times —Black Eagle, Kensington, and Secretary; four times—Campbell; five times—Iona and Herbert; seven times—Governor Ross and

TABLE. PERFORMANCE OF VARIETY CROSSES AND SELFED VARIETIES

Parentage	Number of vines set	Selected for propagation	
		Number	Approximate per cent
Black Eagle X Downing	1	1	100.0
Black Eagle X Mills	6	2	33.3
Brighton (selfed)	27	4	15.0
Brighton X Delaware	7	1	14.0
Brighton X Jefferson	1	1a	100.0
Brighton X Niagara	524	1	0.2
Brighton X Rochester	69	1	1.5
Brighton X (Winchell X Diamond)	198	2	1.0
Brilliant (selfed)	62	1	1.6
Campbell X Triumph	9	1	11.0
Champion X Lutie	68	1b	1.5
Chasselas Besson X Diana	21	1	4.8
Chasselas Rose X Mills	12	1	8.3
Collier X Mills	10	1c	10.0
Concord (Seedless)	4	2	50.0
Concord (Sport)	8	1	12.5
Delago X Diamond	6	1	16.7
Diamond X Croton	1	1	100.0
Empire State (selfed)	42	1	2.4
Franken Reisling X Diamond	6	1	16.7
Gærtner X Mills	3	1	33.3
Goff #19 (open to cross fertilization)	68	1d	1.5
Goff X Iona	8	2	2.5
Gov. Ross X Mills	5	3e	60.0
(Gov. Ross X Mills) X Diamond	7	1	14.0
(Gov. Ross X Mills) selfed	4	1	25.0
(Gov. Ross X Mills) X Winchell	1	1	100.0
Grosse Blaue X Mills	38	2	5.3
Herbert X Worden	86	5f	5.8
Hercules (selfed)	21	1	5.0
Iona X (Vergennes X Jefferson)	5	1	20.0
Janesville (selfed)	143	1	0.7
Kensington X Triumph	7	1	14.0
Kensington X Goethe	8	2	25.0
King Philip (selfed)	6	1	16.7
Lindley X Diana	2	1	50.0
Merrimac (selfed)	20	1	5.0
Mills X Iona	1	1	100.0
Mills X Governor Ross	6	1	16.7
Mills X (Winchell X Diamond)	101	9	9.0
Ozark X Mabel	9	1	11.0
Pinot Gris X Diamond	2	1	50.0
Salem X Worden	80	1	1.3
(Salem X Worden) X Diamond	17	1	5.9
Secretary X Campbell	122	3	2.5
Seibel #2 (selfed)	75	2	2.7
Standard (selfed)	4	1	25.0
Triumph X Delaware	2	1	50.0
Triumph X Dutchess	17	1	6.0
Triumph X Iona	13	1	7.7
Triumph X Mills	74	11	15.0
Triumph X [(Winchell X Diamond) X Jefferson]	7	1	14.0
Winchell X Diamond	37	2g, h	5.4
(Winchell X Diamond) X Jefferson	25	4	16.0
[(Winchell X Diamond) X Jefferson] X (Vergennes X Jefferson)	7	3	43.0
Worden X (Winchell X Diamond)	11	1	9.1
Total	2024	98	

Letter indicates seedling that has been named. a Dunkirk, b Portland, c Westfield.

Triumph; eight times—Worden; ten times—Brighton and Jefferson; twenty-three times—Winchell; twenty-seven times—Diamond; and thirty-five times—Mills. Thus Mills originated by William H. Mills, of Hamilton, Ontario, about 1870, from seed of Muscat Hamburg fertilized by Creveling, has been the leading grape at this Station for producing high quality grapes. Diamond has also being a producer of good quality and Winchell has proved of exceptional value in introducing earliness without impairing quality. Brighton, Jefferson, Iona, Triumph and its seedling Governor Ross, Herbert, Kensington and many others that contain Vinifera characters have made good parents. Preliminary experiments indicate that a few of the pure Vinifera varieties, now being used extensively in our crossing work, will produce good progeny.

In conclusion, it may be stated that to produce desirable seedling grapes, we must depend upon the *Vitis vinifera* species or derivatives of this species for quality and *V. labrusca*, *V. vulpina* and other American species for hardiness. More certain results will be obtained if we depend upon crossing rather than selfing and in using varieties that are known to produce superior progeny.

Bud Selection and the Frequency of Mutations

By E B Babcock, *University of California, Berkeley, Calif.*

THE efficacy of bud selection as a means of improving the type is dependent upon the occurrence of bud mutations; its practicability, upon their frequency. If the above statement holds as a general principle, and it probably does, it is obvious that he who would change existing varieties through bud selection must first discover bud variations, or plants that grew from bud variants, of a relatively permanent nature, i. e., the bud variant must maintain its distinctive characterists when multiplied by vegetative propogation. Such a permanent bud variation, resulting from a mutation in some vegetative cell, is commonly called a bud sport and the general occurrence of bud sports in plants is well known. Concerning the *frequency* of their occurrence, however, very little is definitely known, yet it is a subject of the greatest importance to horticulturists who propose to improve our commercial varieties of tree fruits through bud selection.

Nurserymen, especially, should be keenly alive to the practical aspects of this question. Because of the successful demonstrations of the value of bud selection in the citrus fruits there is an increasing tendency among nurserymen to propagate standard varieties of all tree fruits from selected trees which are known, either from mere observation or actual performance records, to be consistant high producers. Of course, such selection of high-yielding stock trees is commendable, provided proper precautions are taken to in-

sure trueness to type for the variety in regard to characters other than yield. Such nursery stock can then be offered as first class stock of the variety, but nothing more until it has been proven by performance tests of the budded progeny that the character of high yield is actually transmitted. This is what too many nurserymen fail to appreciate and they are rushing pell-mell into an expensive campaign of searching for high producers with the avowed intention of representing the budded progeny as of superior merit because of the high yield of the selected parents. A general warning as to the importance of using proper methods when attempting to carry out in deciduous fruits what has already been accomplished with the citrus fruits was given by Shamel in his paper before this Society last year. It is the purpose of this paper to emphasize the present uncertainty as to what can be accomplished through performance records and the propagation of selected high producers among the deciduous fruits. The motive of the paper is not to discourage extensive experimentation in this field. The more well-planned and carefully executed experiments the better, especially if they are fully reported, with adequate data on the performance of the budded progeny in comparison with the parent trees. But the whole question of the *practicability* of increasing the yield of deciduous varieties through bud selection is still unanswered, and it is this aspect of the subject which it is the duty of horticulturists to keep before the nurserymen and the fruit growers. In the remainder of the time allotted to me, I will present some of the reasons for maintaining an attitude of suspended judgment on this question.

Both species and varieties differ as to the frequency with which bud mutations occur. We are greatly in need of actual data, but presumably there is no horticulturist who would venture to assert that bud sports are as frequent in any deciduous fruit as they appear to be in several of the citrus fruits. Thus far, only two varieties of orange, two varieties of lemon and one variety of pomelo have been intensively studied, and we do not know that bud mutations are as frequent, or of as great practical importance, in other citrus varieties as they appear to be in the five California varieties with which Shamel has worked. But even though all citrus varieties are found to be inherently prone to mutate frequently in their vegetative tissues, it would not necessarily follow that any varieties of apples are equally apt to do so. Furthermore, even if one variety of apple were to produce many bud sports it would be unsafe to infer that all other varieties were equally variable. The proneness of certain varieties of the rose to produce bud sports has been pointed out recently by Pomeroy who states that Killarney, Radiance, and Ophelia are in a mutating stage, more or less unstable, and give rise to numbers of bud varieties. Certain dahlia varieties also have a pronounced tendency to bud mutation. In the potato, according to Oberstein, the Agricultural Board of Silesia found over 5 per cent of the plants in certain fields aberrant in flower color, and Oberstein claims to have proved

that certain varieties of potatoes are prone to show color variations in both flowers and tubers within the same plant. Aumiot, working with the wild progenitors of the potato, has discovered three mutations in *Solanum commersoni* which are resistant to disease. On the other hand, Anthony's report on five years of bud selection for length of flower stem in the double violet, Marie Louise, states: "We seemingly have proved only the existence of asexually inherited differences which probably were present before the experiment was begun. No attempt has been made to find when or how such differences arose."

Of course it is well known that in apples, plums and other deciduous fruits new varieties have arisen as bud sports. But the number of varieties arising in this way is relatively small and it is, therefore, fair to infer that the number of vegetative mutations which favor or cause high productivity are also relatively rare. The point I am making is simply that as yet we lack sufficient data to justify any conclusion regarding the practicability of increasing the yield of deciduous fruits through bud selection.

The danger in assuming close similarity between deciduous and citrus fruits as regards the practicability of isolating high yielding strains through bud selection, is further emphasized by the few experiments that have been made with deciduous fruits. The outstanding work of Whitten in Missouri, Gardner in Oregon, Hedrick in New York, and Crandall in Illinois, all gave negative results in the apple, and in the strawberry only one positive case was reported and that resulted in deterioration of vigor and lowering of yield. While these experiments were of limited scope, only a few varieties being represented, and similar experiments with other varieties may give very different results, still it must be admitted that thus far experimentation has tended only to increase our doubt as to the practicability of increasing the yield of standard varieties of deciduous fruits through bud selection.

The question of the frequency of mutations has received some attention from geneticists. Without going into details we may consider the general bearing of the Drosophila investigations on this subject. However, it may be well to point out in explanation that the great majority of the somatic variations in plants which are transmissible, or, in other words, most vegetative mutations, are due to some sort of change in that portion of the cell nucleus which has been identified as the true germ-stuff, the hereditary material par excellence, namely the cromosomes. And we recognize two general classes of these mutations according to the nature of the change which takes place in the chromosomes. First, there are occasional irregularities in cell division which result in the loss from one cell, and duplication in another cell, of entire chromosomes. Such an event, especially in a complex hybrid, might cause profound changes in morphological and physiological characters. But, in general, mitosis is a remarkably regular mechanical process and it is highly probable that very few bud mutations find their origin in irregularities of chromosome distribution during cell

division. Second, a single locus in a particular chromosome may become so altered that one or more somatic characters are changed. Such changes are called factor mutations. By far the great majority of all the Drosophila mutations are in this class, and inasmuch as many bud mutations in plants affect characters which are known to follow the Mendelian laws of segregation and recombination in plants propagated from seed, we infer that the great majority of bud mutations including those which affect such physiological characters as fruit production, are the direct result of alterations in single genetic factors, i. e., of factor mutations like those studied so extensively in the fruit fly.

The Drosophila investigators have reported about 300 different mutations in the one species studied extensively and during the period of investigation they have counted approximately 30,000,000 flies. This gives a frequency of one mutant in 10,000 flies. But many mutations appear more than once and some are of such an insignificant character that they are not reported, so that they claim a frequency of one mutation in every four or five thousand flies. If we assume for the sake of argument that the same frequency of mutations obtains in the apple, how many trees would have to be tested in order to discover one high producer which is in a true, hereditary sense superior to other trees and hence capable of transmitting its character of high yield to its budded progeny? Obviously we could not expect to find one among 4,000 tested trees, because many factor mutations affect only some morphological character, or characters, and do not affect yield at all. If we assume further that half of the mutations affect yield and that every other one of these tends to increase yield, we have already increased the number from 4,000 to 16,000 trees which must be tested in order to discover one truly superior tree.

We might pursue this line of hypothetical reasoning much farther, comparing the number of chromosomes in the apple or the plum with the number in the fruit fly with reference to the known rate of mutations per chromosome in the latter and the number of bearing trees of the former now in existence. But it all points to the same general conclusion, to wit, that the geneticist cannot hold out much encouragement to those who propose to locate genetically superior deciduous fruit trees by means of performance records and progeny tests.

The present tendency of nurserymen to advertise stock grown from known high producers as capable of furnishing orchards that will yield more than orchards grown from first class stock from healthy trees that are typical of the variety, should be discouraged. Such inferences are at present unwarranted. There should first be some well planned experiments on typical orchards of all the principal deciduous fruits. Then, if the results of these experiments are such as to indicate that performance records and progeny tests are worth having in deciduous fruits, it should not be difficult to interest the growers. However, the keeping of performance records of orchard trees may be well worth doing by

every orchardist if only for the purpose of eliminating drone trees. After performance records had been kept for several years by many growers, it should be possible to locate a number of outstanding trees which could then be propagated for testing. It is desirable that some of our experiment stations undertake investigations in this field in the near future and because of the wide range of material to be covered and the length of time involved, it is a very suitable field for co-operative investigations.

None of the above statements should be interpreted as antagonistic to the idea that bud selection is an important phase of modern fruit growing. The regular practice of bud selection should be encouraged because it will assist in holding varieties true to type and it will increase the chances of discovering new and possibly valuable bud sports and chance seedlings. But the mere fact that bud selection is practiced, is not sufficient to warrant any claims to special or unusual merit in nursery stock. The super-yielding tree of apple, peach or plum, which will beget a super-yielding orchard, has yet to be discovered.

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Methods in Apple Pollination Experiments

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IT is undoubtedly true that pomological investigation has advanced to a stage where it is necessary that more intensive experimentation be carried on. The more gross phases of our problems have been worked upon; those remaining are complex

ones and will require the work of men highly trained in chemistry and physiology before we can hope for their solution. We can see clearly that the research man in pomology of tomorrow must work as much in the laboratory as in the orchard if he is to solve his problems.

But although this condition is true with most of our problems, it is not true with the pollination question. There are many phases of the apple pollination problem that must be worked out in the field. Can we answer these questions intelligently? What varieties of apples are self-sterile? What varieties are the best pollenizers for our common commercial sorts? Practically all one can say in answer is that most of our varieties are self-sterile or partially so and consequently the set is greatly increased by cross-fertilization. We tell the grower to interplant varieties, selecting sorts that bloom at as near the same time as possible. But have we any very specific data which tells us what varieties to interplant? We are finding that there is cross-sterility as well as self-sterility, so this phase of the question must be studied carefully. There is a great deal of uncertainty due to the fact that a variety may vary in its sterility, depending on the locality where grown and on the weather conditions at blooming time. Much of this uncertainty, however, is due to faulty methods of experimentation.

In this paper, some of the field methods used in apple pollination work will be discussed briefly.

Self-sterility is usually determined by one of two methods. To prevent insect visitation, either individual clusters of flowers are inclosed, or the whole tree is covered with a tent. When the "bagging" method was first used extensively, careful temperature measurements were made to determine if the flowers in the bag were under abnormal conditions. Seemingly no thought was given to the possible abnormal light conditions within the bags. The brown paper sacks ordinarily used in pollination work allow little light to penetrate and a number of investigators have shown that the decreased illumination has an unfavorable influence on fruit setting. Heinicke in Cornell Bulletin 393 gives data to show this.

There are at least two possible effects of the reduced light. First, an insufficiency of food for the developing fruit, due to a lowered assimilative power of the leaves in the bag; and second, an inadequate supply of water, resulting from the lowered osmotic concentration of the sap in the spur and leaves bagged. The second factor is probably more important in seasons of reduced rainfall during the period immediately after blooming. Under such conditions, the bagged spurs would be unable to compete successfully for water with exposed spurs having a higher osmotic pull.

Obviously, if one is to use the bagging method, sacks should be selected that allow light to pass through. Heinicke, at Cornell, has used with success translucent white tissue paper bags. They are not as strong as the common brown bags, but by using smaller ones and inclosing fewer blossoms danger from breaking, due to whipping by the wind, will be reduced.

The other method, that of tenting the whole tree, I believe to be the better one. When a tree is covered with a muslin tent to exclude insects, all the blossoms are subjected to practically the same conditions as to light, temperature and humidity. Because of this, results are necessarily more trustworthy than data gotten by the "bagging" method. However, there are practical considerations that make the use of this method difficult. If the trees under experimentation are large and on an exposed site, the wind will play havoc with the tents. To a large extent we are overcoming this difficulty at the West Virginia Station by using dwarf apple trees. This brings up the question, however, as to the effect that dwarf roots may have on sterility.

Much of our data on sterility is of little value because of the small number of flowers used. How small a number of blossoms should be crossed or selfed in order that reliable conclusions may be drawn from the results? Many of our free blooming varieties in West Virginia such as the Rome Beauty normally have only a 5 per cent set. It is clear, therefore, that a large number of blossons must be "worked" if a sufficient number of fruits are to be gotten. In my own work, I have decided on a minimum of five hundred for each cross or self-pollination, if spurs are selected indiscriminately, but a larger number if time allows. If vigorous spurs only are selected a smaller number should suffice, since it is known that the set is larger on vigorous spurs. Heinicke in Cornell Bulletin 393 was able to double the percentage of set by selecting vigorous spurs.

An interesting question arises here regarding the treatment of "selfed" flowers. It is necessary to actually hand-pollinate the selfed flowers? As there is little conclusive data on this, obviously hand pollination is the safer method. If comparisons are to be made with "crossed" flowers, we should emasculate them as well, prior to the selfing.

The weather conditions at blossoming time materially affect the percentage of set. Temperature practically conditions pollen tube growth. It is necessary, therefore, that very accurate notes be taken on the weather during and following the period of blooming in order that the pollination data be properly interpreted. At the West Virginia Station, we are taking notes on wind, sunshine, temperature, humidity and amount of rainfall.

In closing I wish to say a word on the interpretation of data. Should we summarize and average data secured from pollinations made on different days? Assuredly this should not be done, unless the weather conditions following both series were similar. We know that this is seldom the case. If we should not summarize results gotten from pollinations made on different days, we certainly ought not to do it with results gotten in different years. Yet we find many investigators doing this. Theoretically, results should be summarized only from pollinations made simultaneously. Of course, this is not practical. We can, however, make as many pollinations as possible on the same day. Last spring at the West Virginia Station all pollinations were made on the same day. Even

then, pollinations made in the morning and those made in the afternoon are not strictly comparable because of differences in weather conditions following each.

In this paper, I have considered only a few of the field problems dealing with pollination methods. There are others such as methods of emasculation and pollen collection that I have not time to take up here. Some of you may think I have been too severe in my criticism. However, I think that we all feel that we cannot be too exact in our methods. Each time we make them more exact we cut down our experimental error with a resulting ability to form more trustworthy conclusions.

The Fertility and Fruiting Habit in Cucurbita[1]

By John W. Bushnell, *University Farm, St. Paul, Minn.*[2]

Most of the varieties of squash and pumpkin of horticultural importance in America, are either *Cucurbita pepo*, or *Cucurbita maxima*. The genus was subdivided by Naudain (1856) on the basis that all varieties that were cross-fertile belonged in the same species; thus any variety of *C. maxima* appears to be readily crossed with any other variety of *C. maxima*, but does not cross with *C. pepo*. This grouping is a most convenient basis for a study of the genus by plant breeding methods.

The Hubbard squash, as the most important variety of *C. maxima*, has been a subject of experimental studies at the Minnesota Agricultural Experiment Station. The variety appears to be generally heterozygous for fruit characters. The conspicuous variation in the fruits being obviously undesirable from the commercial viewpoint, an attempt has been made to self-pollinate a number of plants for several generations, as a means of securing more uniform strains. As in any breeding problem, one phase of the investigation concerns the sterility and reproductive habits. This paper deals with sterility in the Hubbard squash and the conditions necessary for successful pollination.

Results of Selfing

In Cucurbita the plants are monoecious, so that in hand-pollinating it is not necessary to emasculate; but in selfing, the pollen must be transferred from the staminate to the pistillate flowers. The flowering habit and method of pollinating by hand has been

[1]Published, with the approval of the Director, as Paper 240 of the Journal Series of the Minnesota Agricultural Experiment Station.

[2]Acknowledgment. Experimental work with the squash was begun at University Farm in 1914 by R. Wellington, then in charge of the Section of Fruit and Vegetable Investigations. The writer took over the work as a graduate problem in 1917 and in the present report has utilized the data collected by Wellington prior to 1917.

described in detail by Cummings (1904). The flowers are large, hence the pollen-carrying insects are easily excluded by tying the petals with a small rubber binder. The anthers and stigma being correspondingly large, no technical skill is required to pollinate by hand.

The evidence from the literature on the self-fertility in this genus is meager and conflicting. Bailey (1890) reported that a large number of attempts to self-pollinate squash and pumpkins failed, and concluded that his material must be self-sterile. On the other hand, Cummings reports that he successfully selfed two varieties of *C. pepo.* In regard to cross fertility, these investigators agree with Naudin that within a species the plants are cross-fertile.

In the studies with the Hubbard squash at University Farm, several strains from commercial sources of seed were grown in 1914. An attempt was made to self-pollinate a number of these plants. Only two self-fertilized fruits matured. In the light of Bailey's evidence as to the self-sterility of the species, these two fruits might have been the result of careless technique, particularly as the vines considerably intertwined, and the possibility of accidentally using pollen from an adjacent plant was always present.

To check this point, a similar plot was grown in 1915. During this season all the open-pollinated fruits were picked off when discovered, to encourage the setting of the selfed fruits. With this improvement in technique, 47 selfed fruits matured. The seeds from these self-fertilized fruits were planted in 1916, and the same method of self-pollinating resulted in 58 mature fruits. Similarly in 1917, 117 self-fertilized fruits were secured.

It appeared from these data that the Hubbard squash was at least partially self-fertile. But selfed fruits had not been secured from every plant, and it was possible that in such heterozygous material a proportion were self-sterile, and that some strains were being lost from this hereditary self-steriilty. Therefore, in 1918, only two plants of each strain were used and an attempt was made to self every pistillate flower appearing in the plot. Successfully selfed fruits were secured from every plant. The plants under observation were clearly self-fertile.

These methods were continued in 1919 and 1920, and in addition a large number of crosses made by hand. No self-sterility nor cross-sterility was discovered, except in one weak plant which bore neither viable pollen nor mature fruits. Under conditions such as obtained at University Farm during these six years, this variety of *C. maxima* has been clearly self-ertile.

In the closely related species, *C. pepo*, attempts to self three varieties have been equally successful.

Factors Influencing the Setting of Fruit

Although no hereditary sterility has been evident in the Hubbard squash, or other varieties of *Cucurbita* under field conditions at University Farm, a large proportion of the hand-pollinated fruits have aborted. In general such a condition would be expected, as

a plant normally bears many more flowers than it matures as fruits. But with a blooming period extending over several weeks, it seemed probable that the flowers first appearing would develop into fruits if properly polinated, and that the later flowers would abort. As a matter of fact, when hand-pollinated, a large proportion of the earlier flowers aborted, while on the same plant some of the later flowers developed into mature fruits. This led to a study of each hand-pollination in 1919 and 1920 as a means of determining the conditions at the time of pollination essential to the fertilization and setting of fruit.

Weather. The effective blooming period in this species occurs from about the middle of July to the middle of August. The plants continue to produce flowers until frost, but fruits that set after the middle of August do not mature during the balance of the short growing season in Minnesota. To determine the effect of the weather on the setting of fruits, hand-pollinations were made every day during the first three weeks of the blooming period. In 1919 there was considerable variation in the temperature, moisture and character of the days during this period; in 1920 the weather conditions were peculiarly uniform, each day being dry, sunny and of moderate summer temperature. On only one day each year did the controlled pollinations fail entirely to set. On one of these days (1919) there occurred so violent a storm that the petals were torn and the other flower parts injured. Fourteen flowers were pollinated just after the storm, but none set. During the season of 1920, the protracted dry weather seriously retarded the growth of the plants, reduced the average number of fruits per plant, and decreased the percentage of setting in the controlled pollinations. But even under these conditions of severe drouth, each day's pollinations resulted, with only one exception, in a few mature fruits. These successes show that pollinations may be made under a considerable range of conditions, and that the influence of the weather cannot account for the large percentage of abortion in the first flowers appearing during the blooming period. It may be concluded that the weather at the time the pollen is applied to the stigma, is not ordinarily an important factor in the setting of fruit.

Time of Day. Since normal field pollination by insects usually occurs in the early part of the day, it seemed advisable to determine whether the flower could be successfully pollinated at other periods. Accordingly, hand-pollinations were made at several different periods of the day both in 1919 and 1920. There was no indication from the results that any factor related to the course of the day was involved. Successful pollinations were made at every hour from 6 A. M. to 6 P. M.

Stages of the Receptive Period. A series of careful observations in 1919 showed that the development of the flower was quite independent of the course of the day, so that the petals did not open at any definite hour. As pointed out by Cummings, the flower is open only about 24 hours, and the receptive period of the stigma is thus relatively short. He also found that in the closely related

species of *C. pepo* the pollen tube required six days to reach the egg. At University Farm the style frequently rots after the petals wilt. It was thus possible that the many abortions in controlled pollinations may have been due to the pollen having been applied after the receptive period, or in case of delayed pollination of the pollen tube being caught in the rotting tissue of the style. As a basis for the study of pollinations at different stages of the receptive period, the life of the flower was roughly divided into six periods as judged by the condition of the petals. The 1920 controlled pollinations were recorded on this basis:

Stage of the flower	Number of controlled pollinations	Set	Aborted
Large bud	15	0	15
Bud with petals splitting	85	14	71
Open so that insects might enter	40	5	35
Open	60	19	41
Petals widely spread	201	49	152
Petals wilted	49	2	47
	450	89	361

From these data it appears that the receptive period extends through the time that the petals are open; but that a consistently large percentage of the fruits abort irrespective of the time that the pollen is applied.

Periodicity of Setting. The study of the records of the individual hand-pollinations having failed to isolate the cause of the large percentage of abortion, a more detailed examination of the flower and fruiting habit was undertaken. A measurable difference in the size of the flower on an individual plant was noted. To determine if there was a relation between the size and setting, the diameter of the ovary was measured at the time of pollination on ten plants. Data from a typical plant are tabulated here:

Day pollinated		Diameter of ovary	Result
July	22, 1920	18 mm.	Abort
	24	20	Set
	24	17	Set
	26	20	Set
	27	18	Abort
	27	18	Abort
	29	20	Set
	30	23	Abort
	31	23	Set
	31	21	Abort
August	1	22	Abort
	1	22	Abort
	2	24	Abort

No marked correlation between the size of the flower and the setting was evident in any of the plants studied. In all ten plants, however, the flowers that set group themselves into indefinite periods. Generally the first flower aborted; on only one plant did the first flower set. Then the next one or more flowers set, followed by a series that aborted and then another flower or two that set. One plant which was left open to insect pollination, and followed very carefully in the study of its reproductive habits, showed this same grouping of the flower that set. From the consistent abortion of the first flower and the periodic setting in those following, it appears that fundamental differences are present in the flowers produced during the effective blooming period, differences that are not readily detected by an inspection of the flowers. This periodic and intermittent production of flowers capable of further development seems to be the important factor in the setting of fruits.

SUMMARY

During the progress of breeding studies with Hubbard squash, *(Cucurbita maxima)*, no inherited self-sterility has been encountered; a large number of self-pollinated fruits have been secured each year from 1915 to 1920.

As a consistently large percentage of hand-pollinations have aborted, the conditions at the time the pollen is applied to the stigma have been critically studied to determine the factors influencing the setting of the fruits.

It has been found that successful pollinations may be made (1) under a wide range of weather conditions, (2) at any time of day, (3) at any time during the period that the petals are open.

A study of the flowering habit and the sequence of flower production on ten plants indicates that at certain periods the flowers set if pollinated, while at other times during the blooming period all the flowers abort. A proportion of the first flowers produced by a plant apparently will not develop into fruit under most favorable conditions. This physiological difference in the pistillate flowers appears to be the most important factor in the development after the flowering stage.

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Biennial Fruit Bearing in the Apple

By J. W. Crow, *Agricultural College, Guelph, Canada.*

BIENNIAL bearing is not a fixed characteristic of the Oldenburg and Wealthy varieties. It is brought about by the development in some one year of blossoms on too large a percentage of spurs. Alternate bearing trees commonly show in their fruiting year fruit buds on from 60 to 90 per cent of their fruit spurs. From 30 to 50 per cent of these would be sufficient to produce a full crop. Growths on bearing Oldenburg and Wealthy trees are of six distinct types, based on their position and on the behavior of their terminal buds.

(1) Weak leaf spurs, making 1 to 2 mm. of growth annually. So long as they make only this amount of growth they do not set fruit buds.

(2) Axillary leaf spurs, 1 to 3 mm. in length, produced as lateral growths on blossoming spurs. They rarely produce fruit buds in the season of their origin, but normally do so the following year.

(3) Weak fruit spurs, 3 to 4 mm. in length. They blossom but seldom produce fruit.

(4) Strong fruit spurs, 4 to 9 mm. in length. These bear nearly all the fruit. Individual spurs bear every second year and rarely blossom two years in succession.

(5) Extra long fruit spurs (or shoots). With some varieties shoots from 10 to 200 mm. in length, occasionally produce strong terminal fruit buds.

(6) Non-fruiting shoots of lengths varying from 10 mm. up to 500 mm. or more. The majority of the longer growths on a tree are of this nature.

The percentage (from actual count) of growths falling in each category is as follows:

TABLE I

	mm. 1-2	mm. 1-3	mm. 3-4	mm. 4-9	mm. 10-200	mm. 10-500
1. Alternate bearing tree, in *on* year	2-6	83-96	0	0-.2	0	4-17
2. Alternate bearing tree, in *off* year	2-6	2-8	16-28	59-73	3-9	6-18
3. Annual bearing tree (McIntosh)	1-5	31-34	6-11	29-34	2-3	3-18

To secure annual fruiting it becomes necessary to stimulate the growth of the tree *in the off year* so that a considerable percentage of spurs which would normally produce fruit buds in that season will be forced into categories 5 and 6. Spur behavior will then tabulate as follows:

TABLE II

	Class 1	2	3			
	mm. 1-2	mm. 1-3	mm. 3-4	mm. 4-9	mm 10-200	mm. 10-500
1. Starting with (on year)	2-6	83-96	0	0-.2	0	4-17
2. Stimulated (by pruning off year	1-3	1-4	7-11	18-49	4-6	21-44
3. Next year (estimated)	0	30-40	0	30-40	0	0
4. Result is annual fruiting	0	30-40	0	30-40	0	0

We thus get a tree with two sets of spurs each set of which produces fruit in alternate years. Our experiments show that this result cannot be accomplished by thinning of the fruit, but that it can be accomplished by moderate heading back of small branches *in the off year*. Our experiments show that it can also be accomplished by stimulating the growth of the tree with nitrate of soda *in the off year*. The nitrate requires to be applied very early in the spring for the reason that the large majority of fruit spurs have a very short period of growth (from 4 to 10 days). Our observations lead us to believe that 75 per cent or more of the fruit spurs on Oldenburg and Wealthy have completed their growth for the season *by the time the first blossoms have well set on blooming trees of the same varieties*. Experiments in bud and blossom removal indicate that the date given is certainly the critical period of fruit bud formation for trees *in their on year*. Table 3 shows 79 per cent of fruit bud formation from spurs disbudded before that time and none whatever from spurs disbudded after that time. We suspect that no treatment can be applied after that time which will change the destiny of buds falling in categories 1, 2, 3 and 4 on either bearing or non-bearing trees.

TABLE III

Blossoming as Related to Fruit Bud Formation, Oldenburg Tree, Twenty-five Years of Age.

Dates of blossom cluster removal	Branch No.	1919 Growth		Types of Growths Developed, 1920				
		Strong fruit spurs	Long fruit growths	Short leaf spurs	Long leaf growths	Weak fruit spurs	Strong fruit spurs	Long fruit spurs
5-15-20	1a	125	7	3	0	17	101	4
5-18-20	11a	110	8	5	0	21	83	4
5-19-20	12a	91	6	2	1	11	76	4
5-20-20	12b	121	12	7	0	16	89	3
5-21-20	1b	155	9	19	6	12	116	8
(First blossoms opened								
5-22-20	2	327	24	46	2	43	263	7
5-23-20	3	112	11	7	14	15	89	9
5-24-20	1c	130	8	6	0	19	98	13
(Full Bloom)								
5-25-20	1d	302	15	28	9	61	231	11
5-26-20	11b	404	36	36	21	72	315	31
5-27-20	10a	129	16	43	7	17	81	9
(First Petals Falling)								
5-28-20	10b	124	13	117	13	3	14	6
(Fruit well set)								
5-29-20	5a	117	5	110	27	13	2	0
Critical Period	Total	2247	170	429	100	320	1558	109
5-31-20	9	118	13	128	31	0	0	0
6-2-20	7a	122	10	143	13	0	0	0
6-5-20	7b	105	7	116	18	0	0	0
6-8-20	4a	110	6	123	11	0	0	0
6-21-20	6	185	12	199	16	0	0	0
Check	4b	209	11	236	17	0	0	0
Check	5b	188	9	210	14	0	0	0
Check	8	337	22	384	32	0	0	0
	Total	1374	90	1539	152	0	0	0

A State Program for Landscape Extension

By F. A. AUST, *University of Wisconsin, Madison, Wisi.*

IN order to adequately discuss a state program of landscape extension we must consider the background and discuss the fundamentals of the art commonly known as landscape architecture, landscape design or landscape gardening. If we were to consider these matters fully we would necessarily have to go to the realm of sociology, economics, political economy, botany, ecology, plant physiology for these are all vital to the subject of landscape extension, but the scope of this paper will only allow the briefest survey of the relation of these allied subjects.

First, let us consider our need for natural beauty for the great out-of-doors for "free landscape." In the opening chapter of Hubbard and Kimball's Introduction to the study of Landscape Design, we find these thoughts expressed. We, as a city dwelling race existing among man-made surroundings and man-made objects are very new in this long history of evolution. We have always found it necessary to obtain from our surroundings two things, our economic needs—usefulness, and inspiration of that which pleases the eye-beauty. All our modes of living as well as our progress up the ladder of civilization, have consisted of making over our environment to serve these two purposes. From earliest times man has been engaged in subduing Nature's forces and making over his surroundings so that they gave him practical and aesthetic satisfaction. Today we find ourselves no longer isolated and overpowered by nature, but instead in many cases hemmed in, hampered, and oppressed on every side by the work of our own creation. Today the city dweller seeks and finds relief in the great out-of-doors, in the "world still ruled by the powers of untouched nature." It is significant that man should find this relief here. So long as man is in contact with nature, even though not primeval nature, this need seems to be sufficiently well met, but if a race of city dwelling men is to exist for any length of time, it must find relief from machine industry and physical oppression in the primitive landscape not made by the hand of man. And if this race is to advance, if civilization is to develop, men must have the opportunity of stimulating their imagination, "of allowing it to lose itself in the infinitely complicated, magnificent and ordered whole of which they are a part, the glory of which is their rightful heritage."

We have said that man derives two things from his natural surroundings—usefulness and beauty. Beauty even other than natural beauty seems essential. The philosopher Croce, has defined beauty as "successful expression," "the supremacy of higher over lower." If we accept this definition we can well see why man longs for the beautiful, or what he adjudges beautiful. As civilization has advanced, man's ideals of beauty have also advanced.

In our intense efforts to subdue Nature's forces—to develop our natural resources, we have laid too much emphasis perhaps upon the acquisition of the useful at the expense of the beautiful. We are unbalanced. On every hand we see man's desire of the beautiful. We see this in the present unrest, and the dislike for ugliness, due to the cramped conditions which man has himeslf created.

With this as a background let us consider briefly of what landscape extension consists. We may define landscape extension in its broadest sense as the development of the appreciation and the furthering of the practice of the fundamental principles of the art of landscape design, by the citizens of every community. In the nth degree it is democratization of the art of landscape design.

Landscape design, landscape architecture or landscape gardening, may best be defined by the definition given by President Emeritus Eliot when he says: "Landscape architecture is primarily a fine art, and as such its most important function is to create and preserve beauty in the surroundings of human habitations and in the broader natural scenery of the country." Or as it is defined by Professor Waugh, "it is the fitting of land for human use and human enjoyment in such a manner as to secure the maximum of beauty, combined with the maximum of practical utility." The term "maximum of practical utility" is all inclusive . It would ensure the proper selection of plant materials considered from the ecological, physiological, and climatological viewpoints. It includes the proper design of road and street systems, considered from the economic and engineering standpoint. It includes the proper design, location and distribution of community centers, planned for the health, welfare and amenity of the citizen. It includes city planning and rural planning as well as problems in home grounds and gardens.

The Function of the Designer

Thus far we have considered the relation of landscape design and landscape extension to society as a whole. Any consideration of a state program of landscape extension must necessarily consider the individual practitioner or landscape architect as well The function of the landscape architect is in every detail similar to that of the architect of whom the eminent Englishman, Charles R. Ashbee, has so well said: "It is his business to study the life that goes on around him to understand that life and to make it a little happier here, a little less squalid there, and a little more beautiful in other words, to help people live while he himself is living and creating at the top of his bent. He must interpret and try to understand the different social, political, and religious movements through which we are passing. His own work—though he do but little—will be better by knowing and understanding the life that goes on around him and it will be a finer interpretation of the life of the individual, or the community, whom he serves. It must ever be his aim to render attractive the objects he has at heart." This is the real function of the landscape architect, designer or gardener. This is what he should be paid for—it isn't always what he *is* paid for. But it has been the writer's experience from coming in contact with the many professional men that any program of landscape extension which widens the field of the profession, which teaches the public to appreciate what is best in landscape art, and which actually demonstrates to communities at large the value of professional assistance, will be heartily welcomed. But a clear line of demarcation must be drawn in every demonstrational problem of what should best be handled by the private practitioner and what should be undertaken by public agencies.

Aims and Purposes of Landscape Design and Landscape Extension

The most comprehensive ideal for the art of landscape design is the orderly arrangement of the entire surface of the earth in accordance with plans carefully providing for every interest involved, and solving all problems from the standpoint of community welfare rather than from the standpoint of private gain. Perhaps such a program seems socialistic, not to say Utopian, but where civilization has developed to the highest degree we find it tending toward this ideal.

Perhaps the ideal can never be wholly realized, but it can be approximated. Each problem solved is a round in the ladder leading us upward. Thousands of private and public problems had to be solved before the public would have sufficient faith in city planning to enact some of the necessary legislation. Many rural problems, county park systems and state parks and highway plans, had to be worked before rural planning was conceived. Today five or six states have some type of rural or regional planning laws. Our national highways and national parks and waterways will soon necessitate a national landscape plan. But the making of a world plan must await the development of the league of nations—a world republic, with a system of international police.

Obviously landscape extension can assist only in a very small portion of the work outlined, but the quantity of its output can be many times increased by multiplying the efforts of every individual and agency in any way allied to landscape extension work, and are the salient subjects in any program of landscape extension.

The State Program

The difficulty in operating any state program for landscape extension is organization. First the right leaders with sympathetic and resourceful workers must be found. How the work is then organized must be governed to a great extent by the existing agencies and state departments previously organized. One thing must be kept in mind. The main function of landscape extension is education. Where state departments exist, such as department of agriculture, conservation commission, forestry commission, highway commission, state architect and the like, the organization of landscape extension work must plan for the co-operation and coordination of the efforts of these departments. In the assumption of the duties of co-operation and co-ordination, no police duties should be assumed.

Co-operation and co-ordination can in some instances be definitely planned, but more often is a process of evolution, and years of effort on the part of the various workers in landscape extension. Duplication of effort should always be avoided. Every state has numerous organizations such as good roads association, state historical societies, state federation of women's clubs, horticultural society, society of landscape architects, archæological societies, wild life society, wild flower organization, boards of com-

merce and commercial clubs, which are useful agencies and important factors in a state program of landscape extension.

The educational functions of any extension program are very well defined. They are:

(1) Research in landscape problems.
(2) Demonstration.
(3) Lecture work.
(4) Publication.
(5) Follow up work.

There are many phases of landscape gardening still in the "guess work" stage. Such problems as the effect of trees and shrubs on drifting snow, hardiness of shrubs in various sections, effect of various species of trees on adjacent crops, and methods of propagating certain ornamental plants must be solved if landscape extension is to be a success. These and many other problems challenge the research workers in landscape gardening.

We are told that every good impulse must bear some fruit else its successor is weakened. For this reason, if for no other, demonstration work is essential. A community whose enthusiasm along these lines is aroused if not given an immediate opportunity for action, is often injured rather than benefited. Thus a demonstration will often crystallize public opinion and give an opportunity for community action. Besides this, demonstrational work teaches the value of the practical combined with the beautiful; it gives an opportunity for research; and it popularizes the work of the profession. The following types of demonstrational work have been found effective in our work in Wisconsin.

A. Rural Problems.
   1. Farm home grounds under a Smith Lever project.
   2. Rural school grounds.
   3. Rural community center plans in newly developed districts.
   4. Preservation of existing trees in the location or relocation of new highways.
   5. Rural parks and picnic grounds.
   6. Planting of trees along state trunk highways.
   7. Rural cemeteries.

B. Town or City Problems.
   1. School grounds and public buildings.
   2. Factory grounds.
   3. Street tree improvement.

In any demonstrational problems we must always carefully consider the relation of such work to the community and to the private landscape architect. We should always ask the question: "Should the work be done by a private practitioner or through the extension service?" No exact rules can be established governing such decisions, but each problem must be carefully investigated and then a decision reached.

With us in Wisconsin it is a well-established precedent that the local community should bear its share of the expense in the execution of every demonstrational problem. This in itself insures local cooperation. The following points are considered in each problem coming up for acceptance: (1) Is the project educational? (2) Is it of greater public than private gain? (3) Are funds available so the problem can be turned over to a private landscape architect? (4) Are funds available for the execution and maintenance of the project? (5) Are there responsible parties to provide for the maintenance?

Publication work is of two distinct classes. (1) Practical. (2) Inspirational. Here it is necessary to provide that all the essential research work is completed before any inspirational publicity campaign is launched.

In fact it is preferable to have all the practical literature available or ready before any publication of an inspirational nature is undertaken. The two types are very distinct and one publication can seldom be made to serve the same purpose. Much of the station literature fails absolutely to inspire because of the poor or inadequate illustrations used. Research and first hand information of local conditions, even to the minutest detail, must always precede inspirational material, or the superstructure will be heavier than the foundation will carry. Lectures should usually be illustrated by high-grade colored lantern slides which in themselves are æsthetically perfect. The value of before and after pictures has been clearly demonstrated, and demonstrational work is the best source of such illustrations. After the ground work of landscape extension is completed, group lectures as a part of a local campaign are a very effective means of concentrating the efforts along landscape lines and securing the accumulative effect of community action.

Follow-up work is always necessary. In the first place, every community contains within itself all the elements necessary for the control of its own development, and extension work should furnish the expert assistance on special problems when the desire for such service expresses itself. The execution of a project is the duty of the community, but the responsibility of the extension service does not cease when the execution work is completed. The inspiration and often additional advice to carry on and maintain the project, must come from the extension service. A project must be planned by democratic methods and maintained by paternalistic methods until success is assured. The follow-up work is of vital importance to any demonstration and adequate provision must be made for same.

A state program of landscape extension then must be primarily educational, but this education extends and must be felt throughout the entire fabric of the political and geographical unit. It must reach the individual and aid him in a keener appreciation of the art, and awake in him a desire for the best possible surroundings; it must serve the rural community whether it be the economic unit of a trading center, or a political unit of a township. It

must aid in the direction of the landscape planning of the county and help in the beautifying of the highway system of the state. It may often through influential citizens direct the necessary legislation to make the landscape work of the state a success. The rural planning law of Wisconsin is such a piece of co-operative legislation. It must often help in the organization of societies, or the co-ordination of the work of other societies. The Wisconsin Chapter of Friends of Our Native Landscape, a non-political society to further the preservation and conservation of our native landscape, was largely due to the efforts of landscape extension. Thus we see that any state program of landscape extension must be first of all flexible, it must be comprehensive, and primarily and foremost educational in nature.

Extension Work in Landscape Gardening

By F. A. WAUGH, *Agricultural College, Amherst, Mass*

LANDSCAPE gardening is here understood as an art of design and as such distinct from horticulture or the practical art of growing plants. To quote the school book definition, "landscape gardening (or landscape architecture) is the art of improving land for human use and enjoyment in such a manner as to secure the maximum of utility combined with the maximum of beauty."

OBJECTIVES

The principal objectives to be held in mind by the extension worker in landscape architecture seem to be the following:

1. To inculcate a love and reverence for the native landscape. This is fundamental, yet there are large areas in America where this fundamental appreciation of the native landscape is unfortunately weak.
2. To secure the reservation of suitable portions of the native landscape, and of places of historic interest, in state parks, state forests, county parks, municipal parks and forests, and in other forms.
3. To extend the knowledge of landscape gardening and the possibilities of its service in domestic life and in the development of public property, and in this connection especially to call attention to the services available from professional landscape gardeners, architects and engineers.
4. To promote the development of better home surroundings on farms. This has reference to the total physical equipment of the farm home.
5. To promote the similar improvement of home surroundings in towns and cities. (As the first duty of an agricultural college is to the rural population it is usually advisable to emphasize number 4 rather than 5.)

6. To promote the development of better community equipment, such as better school grounds, play grounds, fair grounds, neighborhood parks, cemeteries, roads, etc. This is perhaps the most important field of extension work in landscape gardening.

Field of Operations

Any extension worker in landscape gardening of course faces first of all the problem of finding himself a place where he can be of immediate service in his own state. If he is employed in the extension service of a state agricultural college he may quite properly make his first attack upon the improvement of farm home grounds. This is technically a fairly simple problem, but practically the difficulty of getting substantial results is very great and may well challenge the metal of the cleverest worker.

After farm home grounds the next field of endeavor may very well be rural school grounds. Here the technical problem is more interesting and the methods of approach usually easier.

Next comes the problem of country playgrounds, either in connection with school grounds or in some other association, or separate. In this connection should be considered the feasibility of developing country clubs for country people.

Country roads are of the utmost importance and very great improvements are possible. These improvements are not confined by any means to simple engineering phases. There are to be considered all questions of roadside planting and the much wider problems of preserving and exhibiting the native scenery along country roads; also the much more serious and difficult problems of new roads and new road locations. Much remains to be done in this field, and much is possible.

Country parks and picnic grounds and reservations of local scenery are of great importance. The extension worker must be fully alive to every opportunity of this sort and should devote a considerable amount of his effort to developing projects in this field to the utmost of his opportunity.

State parks and similar large projects should not by any means be forgotten. Every progressive state is coming to understand that the reservation of important tracts of fine forests and other scenery and the preservation of places of historic interest, are of great importance to the state at large. Every state has valuable scenery and historic monuments and the simplest patriotism demands that they shall be preserved inviolate to future generations.

Public grounds generally offer a field in which a state extension specialist should do a considerable amount of work. Here would be included county courthouse grounds,, the grounds of all state institutions, county fair grounds, etc., etc. There is hardly a state in which such parcels of public property are not numbered by hundreds, yet the logical improvement of such public holdings according to well developed plans has yet been undertaken only in a remarkably small number of instances.

Public cemeteries present a special problem, not so much in the technical character of the designing required as in the proprietor-

ship of the holdings. It is sufficiently obvious that most public cemeteries should have much better care than they are now getting and that the recommendations of a specialist would be most valuable wherever they can be followed.

METHODS

There are four principal methods which have been tested in extension work, as follows:

1. Lectures may be given of a practical or inspirational nature. These have some value when used in connection with other methods. When used alone the lecture method is hardly worth the time and effort spent upon it.
2. Bulletins may be published dealing with various phases of landscape work. These have more permanent value.
3. The organization of clubs and competitions is sometimes worth while. Home garden competitions have proved very effective in many towns. Projects of this sort should be regarded mainly as pioneer work to be followed up by other methods.
4. Professional assistance may be given on going works of landscape gardening. In this case the extension worker adopts practically the same relationship as the professional landscape architect toward his clients, and gives such advice, provides such definite plans, and gives such superintendence to construction as will best secure a satisfactory finished result.

In general we consider this fourth method most effective, though it should be accompanied by suitable lectures and bulletins, and though it must always be borne in mind that the projects carried out are intended to be primarily of educational value.

Considerable tact must be exercised therefore to see that (1) projects are not taken on by the extension worker which might be put into the hands of a regular, practicing professional landscape architect or engineer, and (2) to see that the work does not fall into vain repetition, it being necessary to distribute such educational projects throughout the territory served. It is not considered necessary or desirable for the extension service to do all the work that needs to be done, but merely to carry out convincing examples of work which will enable lay citizens to do better work on their own account, or which will preferably induce such lay citizens to employ professional landscape architects on their own account.

It has been found desirable in practice to charge all the expenses of such operations on concrete projects to the clients, whether they be private persons or municipalities, boards, or commissions.

Our experience is that live extension of this character upon going projects as described above, has a very valuable reaction upon instruction work at home within the department which maintains such extension service.

ORGANIZATION

It is desirable that extension work in landscape gardening should be directed by a college department of landscape gardening (or landscape architecture) within the college or university. Such a department should have its own definite status within the college, that is, it should be organized as a separate subject matter department. Courses of study in landscape gardening should be offered to resident students, though professional courses for the training of landscape architects should be undertaken only in a very few specially selected universities. It is quite desirable, however, that each department doing extension work should have a definite status upon the college campus and a firm footing in the college organization.

In a certain number of institutions it will be practicable to undertake extension work in landscape gardening from a department of horticulture within which a division of landscape gardening has not been clearly differentiated, but this plan is distinctly less desirable.

Under any plan of organization it is deemed positively necessary that the extension specialist in landscape gardening should be a man of considerable personal ability and fundamentally trained in a professional course in landscape gardening. It is now well understood that in every line of work the extension specialist should be a specialist in fact. The danger of sending out men who are not firmly grounded in fundamental principles is well understood, and nowhere is this danger more real than in the field of landscape gardening. This necessity is all the more urgent where the work is undertaken through a department of horticulture rather than through a college department of landscape gardening.

Such an extension specialist needs to be trained not merely in the simple elements of landscape gardening as applied to home grounds decoration, but he especially needs to have a broad understanding of civic art (which includes city planning and country planning) and an equally good grounding in the social principles involved in this civic art. If this looks like a rather large requirement it may be said that there are now several colleges in the country where training of this scope and quality is being given.

It may be assumed that extension work in each case will begin with one specialist, but it is believed that many progressive states will soon be in a position to use several men in the field of landscape gardening. This extension of the organization will come all the more rapidly if methods of work are adopted whereby the university itself does not pay the entire charge. We have found in our work in Massachusetts that it is feasible to charge most of the expenses of such extension work to the organizations and communities served. If the bills are paid in this way outside the college it will be found much easier, naturally, to increase the working staff.

Exception

In closing, attention may be called once more to the distinction drawn between the horticulture of ornamental plants and the art of landscape design. In a considerable number of instances extension work has been undertaken in the former field, though sometimes under the latter name. The dissemination of a better knowledge of ornamental trees, shrubs and herbaceous plants is perfectly good work and need not be checked. It seems to us, however, after long study and experience, that such work should go hand in hand with the principles of design, but that the latter is everywhere more important because more fundamental.

Farmstead Planning

By F. E. McCall, *Agricultural College, Brookings, S. D.*

THE field service of our agricultural colleges can well be directed toward lines that make country life more enticing, more beautiful and more joyous. In fact they should include in their service such projects as meet the general needs and longings of the country people.

Country life implies not only better farming conditions, but also better homesteads, contented home life, and pleasant home surroundings which are not marketable commodities. Yet there is no doubt but that beautiful and comfortable homes do satisfy a part of our nature that nothing else can. They tend to beget contentment of mind and refinement of spirit. They stimulate patriotic zeal and promote love of home that make men willing to sacrifice when necessary in its defense. Many country homes are well provided with such comforts, many others have lost much, and many more have nothing beyond their limits and power to produce, to hold their occupants to them.

On many a prairie homestead the dwellings are not adapted to open windswept conditions. The settlers have worried along with makeshift structures and in many instances are now living in these patched up relics of the past. There are no evergreens and shade trees. No flowering plants and shrubs are found near the buildings, no vines run over the doors and windows. There are neither walks nor well-defined drives, nor is there a good open expanse of sod set aside for a house lawn. Then all this nakedness is amplified by the magnitude of the great flat outdoors.

In a drive about over most any section of the state, one can also find homes of wealthy farmers that could have been very much improved if the free advice of some specialist from the state agricultural college had been taken.

In planning farmsteads in South Dakota we have aimed to produce beauty as the by-product of utility and convenience. We have worked on the principle that in the farmstead the same as in

a park or other landscape, the design of a house, a dress or piece of furniture, the completed product must not only be ornamental but useful as well, and must satisfactorily serve the purpose for which it was intended.

Many new homes have recently been built and many more will be built in the future. The mistakes and triumphs of these will in their turn be passed on for the next generation to cope with or to enjoy. The present generation should, therefore, feel the obligation to build wisely for the future.

The Northern Great Plains have limitations in plant growth that must be recognized. It is difficult to maintain green lawns and flowering shrubs through summers of limited rainfall, rather dry autumns followed by open and severely cold and blusterous winters. However, where artificial watering or proper soil culture is provided until the plants are well established, the reward is usually a rapid growth and quickly attained luxuriance. The great problem is to select such plantgrowth as will give satisfactory general effects without too much detailed care.

There are three main points which must be observed if success is to be hoped for. It is safe to say that at least ninety per cent of the failures in tree planting are due to the fact that one or all of these features have been overlooked. The three points are as follows:

1. The soil must be thoroughly prepared before planting;
2. Only such species of trees or shrubs should be used as are known to be hardy in the district and suited to grow in the particular kind of soil and in the situation where it is desired to plant them.
3. A certain amount of cultivation after planting is absolutely necessary. This cultivation must be carried on until the trees are well established and able to grow without further care.

The prairie grower cannot depend much on the general garden literature for his information for most of it is not applicable to prairie conditions. He must discriminate between the general principles of arrangement and culture applicable everywhere and that adapted to his own situation. Then he must regard the materials and the attention they need in a climate where they will meet summer drought and winter cold.

Farmstead planning as practiced in South Dakota includes the location of buildings, water supply, drives, walks, trees, shrubbery and every other feature which contributes to the outward convenience and ornamentation of the place. The exterior design of the buildings and their interior arrangement and equipment have been omitted except where it is necessary to show the relationship of the various structures.

It is well-recognized that no set of farm plans is suitable under all conditions. Each type of farm means some variation in its building requirements. A dairy farm needs a set of buildings different from a wheat farm. The topography of the land and the prevailing winds are also influencing factors. No building can be

discussed intelligently apart from its surroundings. The best placing of the farm house depends upon the location of the barns and outbuildings. The relation of the buildings to one another to the gardens, shelterbelts, sunlight, drainage, roadways, views, trading points, schools and churches should all be given due consideration. A general farm scheme that unites into one workable system; lands, barns, dwellings and plantings, is the first step in the proper development of any property. Each improvement will then take its place in the final scheme and permanent economy and service will result. So many factors of a purely local character enter into each individual farmstead plan that no set of rules applicable in all cases can be laid down. However, before developing the plan, the following suggestions should be carefully considered and as many of the features incorporated as is consistent with the type of farm under consideration.

The farmstead in general.

1. Locate the buildings near the center of one side of the farm, giving due consideration to other advantages. (Locate on the side of the farm nearest the school, town and church.)
2. Arrange the buildings about an open court for accessibility
3. Locate the buildings on a slight elevation whenever possible so as to give drainage away from the buildings.
4. Construct buildings from the standpoints of necessity, convenience, permanency, beauty and future enlargement.
5. Place buildings just far enough apart to provide sufficient lot room as a protection against fire and not to render the passing back and forth unnecessarily arduous.
6. Provide drainage for buildings and lots.
7. Avoid needless fences and gates on account of cost, maintenance, inconvenience and general appearance.
8. Protect the buildings and lots from the winter winds by a good shelterbelt of trees.
9. Beautify the home grounds with ornamental trees, shrubs, vines, flowers and a good open lawn.
10. Provide a water system under pressure with a large available supply. Pipe the water to buildings and lots where needed.
11. Provide a well kept drive and entrance.
12. A south and east slope is desirable for a building location.
13. Give the farm a name.

The house.

1. The house should be readily accessible to the main highway. It should stand out as the central and most conspicuous feature of the farmstead.
2. The house should be well separated from the other buildings yet accessible to all.
3. As far as possible the house should command a view of all other buildings.

4. Buildings most necessary to house should be located near it, yet readily accessible to drives and open court.

5. The garden should be handy to the house. It should provide sufficient fruits and vegetables for the family needs.

6. Provide a good septic tank for sewage disposal.

Outbuildings and lots.

1. Barns and lots should be on the side of the house farthest from the public road and screened from view as much as possible by use of trees.

2. The barns should be readily accessible to lanes, lots and fields.

3. The shop and machine shed should be convenient to house, barn and fields. The machine shed should be located so that implements can be taken up or dropped en route to or from the fields.

4. The corn crib and granary should be located near the feeding place that calls for the bulk of its supply.

5. A pasture should be adjacent to the barns.

6. Locate barns and lots so that odors and flies are not drifted to the house by the prevailing winds.

The following is a planting list of the trees and other plants most suitable for South Dakota conditions. A model plan has been used with slight variations on two hundred and fourteen farmsteads. This plan provides for simplicity and convenience in arrangement, economy in upkeep, and of outstanding general appearance. The plantings and their arrangement are in keeping with the prairie spirit of landscape gardening.

SUGGESTIONS FOR PLANTING AND CARE OF TREES AND SHRUBS

1. Plant hardy trees and shrubs.
2. Have ground broken deep for two years preceding planting. Fertilize with well rotted barnyard manure.
3. Plant in the spring.
4. If hardpan is close to the surface, it is best to loosen it up with a small blast of dynamite.
5. If dynamite is used, settle the ground thoroughly before planting by filling hole with water.
6. Do not let the soil around the trees freeze dry in the fall.
7. Cultivate the young trees until they shade the ground.
8. Plant windbrakes at least 100 feet out from the buildings.
9. Plant flowering shrubs so they may have protection from winds.
10. Plant trees, shrubs and vines so as to hide from view the objectionable buildings, etc.
11. Leave large open lawn about the house by planting trees and shrubs about the borders.
12. Plant hardy perennial flowers.
13. Select your trees and shrubs from a reliable nursery near home.

14. Mulch your trees for winter and cover those that are not fully hardy.
15. Make a definite planting plan, then plant according to that plan.
16. Plant a few evergreens for winter effect. Do not expose evergreen roots to the air when planting.
17. Plant windbreaks on the south and west sides of the orchard.

Ornamentals for South Dakota

In this list "Lg." means large growth, 30 feet and over; "Med." means 20 to 30 feet in growth; "Sm." means small growth, under 20 feet.

1.	Med.	Green ash	Fraxinus lanceolata
2.	Med.	White ash	Fraxinus alba
3.	Sm	American mountain ash	Sorbus americana
4.	Med.	European mountain ash	Sorbus
5.	Med.	Aspen	Populus tremuloides
6.	Med.	Baccata	Pyrus baccata
7.	Lg.	White birch	Betula alba
8.	Lg.	Black or river birch	Betula nigra
9.	Lg.	Cut leaf weeping birch	Betula alba laciniata pendula
10.	Med.	Basswood or American linden	Tilia americana
11.	Med.	Buckeye	Aesculus glabra
12.	Med.	Boxelder	Acer negundo
13.	Lg.	Cottonwood	Populus deltoides
14.	Med.	Wild black cherry	Prunus serotina
15.	Lg.	White elm	Ulmus americana
16.	Med.	Red elm	Ulmus rubra
17.	Lg.	Chinese elm	Ulmus pumila
18.	Sm.	Hawthorne	Cratægus mollis
19.	Med.	Hackberry	Celtis occidentalis
20.	Sm.	June berry	Amalanchier canadensis
21.	Med.	Honey locust	Gleditsia triacanthos
22.	Med.	Mulberry (Russian)	Morus tatarica
23.	Sm.	Weeping mulberry	Morus tatarica pendula
24.	Lg.	Soft maple	Acer dasycarpum
25.	Med.	Russian olive	Elæagnus angustifolia
26.	Med.	Burr oak	Quercus macrocarpa
27.	Med.	Red oak	Quercus rubra
28.	Sm.	Siberian pea	Caragana arborescens
29.	Lg.	Norway poplar	
30.	Lg.	Northwest poplar	Populus canadensis
31.	Lg.	Silver leaf poplar	Populus alba
32.	Lg.	Lombardy poplar	Populus italica
33.	Lg.	Carolina poplar	Populus deltoides carolinensis
34.	Med.	Black walnut	Juglans nigra
35.	Sm.	Laurel leaf willow	Salix laurifolia
36.	Lg.	White willow	Salix alba
37.	Med.	American golden willow	Salix vitellina
38.	Lg.	European golden willow	Salix vitellina aurea
39.	Lg.	Niobe weeping willow	Salix pendula nova
40.	Sm.	Ural willow	Salix uralensis
41.	Med.	Colorado blue spruce	Picea pungens
42.	Lg.	Black Hills spruce	Picea canadensis
43.	Med.	Koster blue spruce	Picea pungens kosteriana
44.	Lg.	Bull pine	Pinus ponderosa
45.	Med.	Jack pine	Pinus banksiana
46.	Lg.	Scotch pine	Pinus sylvestris
47.	Lg.	Austrian pine	Pinus austriaca
48.	Lg.	Silver fir	Abies concolor
49.	Sm.	Dwarf mountain pine	Pinus montana

Shrubs

The large shrubs are over 8 feet high, the medium ones are 5 to 8 feet, and the small ones under 5 feet high.

50.	Sm.	Japanese barberry	Berberis thunbergii
51.	Med.	Buckthorn	Rhamnus catharticus
52.	Med.	Burning bush	Euonymus europæa
53.	Lg.	Buffalo berry	Shepherdia argentea
54.	Med.	Van Houttei spirea	Spiræa vanhouttei
55.	Med.	Dwarf caragana	Caragana pygmæa
56.	Med.	Yellow flowering currant	Ribes aureum
57.	Sm.	Indian currant or coral berry	Symphoricarpus vulgaris
58.	Sm.	Snowberry	Symphoricarpus racemosus
59.	Lg.	High bush cranberry	Viburnum opulus
60.	Med.	Red dogwood	Cornus alba sanguinea
61.	Med.	Yellow dogwood	Cornus alba elegantissima
62.	Med.	Siberian red dogwood	Cornus alba siberica
63.	Lg.	Common elder	Sambucus canadensis
64.	Med.	Golden elder	Sambucus nigra aurea
65.	Lg.	Cut leaf elder	Sambucus nigra laciniata
66.	Lg.	Red fruited elder	Sambucus racemosus
67.	Med	Hardy hydrangea	Hydrangea paniculata grandiflora
68.	Lg.	Tartarian bush honeysuckle	Lonicera tatarica
69.	Lg.	Red bush honeysuckle	Lonicera tatarica grandiflora
70.	Lg.	White bush honeysuckle	Lonicera tatarica alba
71.	Med.	Morrows honeysuckle	Lonicera morrowii
72.	Lg.	Japan tree lilac	Syringa japonica
73.	Lg.	Hungarian lilac	Syringa josikæa
74	Med.	Persian lilac	Syringa persica
75.	Med.	White persian lilac	Syringa persica alba
76	Lg.	Common purple lilac	Syringa vulgaris
77.	Lg.	Common white lilac	Syringa vulgaris alba
78.	Lg.	Black haw	Viburnum prunifolia
79.	Med.	Snowball	Viburnum opulus sterilis
80.	Sm.	Spirea Anthony waterer	Spiræa anthony waterer
81.	Med.	Ash leaf spirea	Spiræa sorbifolia
82.	Sm.	Thunberg spirea	Spiræa thunbergii
83.	Med.	Billard spirea	Spiræa billardii
84.	Lg.	Smooth sumach	Rhus glabra
85.	Lg.	Smooth cut leaf sumach	Rhus glabra laciniata
86.	Lg.	Staghorn sumach	Rhus typhina
87.	Lg.	Staghorn cut leaf sumach	Rhus typhina laciniata

Vines

88	Virginia creeper	Ampelopsis quinquefolia
89.	Clematis	Clematis paniculata
90.	Matrimony vine	Lycium chinensis
91.	Bitter sweet	Celastrus scandens
92.	Wild grape	Vitis vulpina
93.	Beta grape	Vitis vulpina beta

94. Roses—Hardy, Harrison Yellow, Siberian Rose or Rosa Rugosa, Madame Plantier. With suitable covering—Magna Charta, General Jacqueminot, Marshal P. Wilder, Paul Neyron, Mrs. John Laing, Prince Camille de Rohan.
With suitable protection:
Climbers—Prairie Queen, Dorothy Perkins.
Ramblers—Crimson Rambler, Baby Ramblers.

95. Perennials—German and Japanese iris, peonies, single and double tiger lilies, phlox, larkspur, day lilies, yucca, shasta daisy, oriental poppies, gaillardia, golden glow, columbine.

Pruning Schools in Ohio

By F. H. Beach, *University of Ohio, Columbus, Ohio*

THE pruning school as conducted in Ohio is a practical development of the old pruning demonstration. It includes discussions and demonstrations and in addition offers those attending an opportunity to secure pruning practice under the direction of a specialist. Follow up records show that the results of pruning schools have been more far reaching than the straight demonstration method of instruction.

The pruning school idea was first tried in Ohio in 1919. Two schools were held that spring in Lawrence County and were attended by 35 people. Last winter and spring 28 schools were held in 8 counties with a total attendance of 532. It appears that this record will be exceeded during the coming season.

An effort has been made to locate pruning schools only in communities needing the instruction and ready to support the work. General plans are laid by the extension specialist. Local arrangements and advertising are handled by the farm bureau concerned through their county agent. In advertising the school it is urged upon those who attend to come prepared to work and to bring along their pruning tools.

Schools have been held for a half day, full day and two day sessions depending upon local conditions. Schools are located in a community where typical young and old trees of varieties adapted to the locality can be worked on. Sometimes these conditions can be found in a single orchard but often the school moves to two or more orchards in the community during the session.

The extension specialist takes charge of the school. At first pruning principles are discussed. Following this discussion the specialist prunes one or more trees as a demonstration. Those attending the school are then assigned to trees and their work supervised by the specialist with the assistance of the county agent. During the session the specialist gives several demonstrations to explain the pruning of various types of trees. The predominating varieties found in the community are studied in this manner. The problems of handling young and old trees within these varieties are discussed and the pruning methods demonstrated. Those attending the school are given a chance to work on as many types of trees as conditions permit.

Following is a brief report of how the pruning school idea developed from the pruning demonstration.

Three years ago a pruning demonstration was held at the W. A. Knight orchard near Athalia, Lawrence County, Ohio. This orchard was a typical Rome Beauty orchard of the Southern Ohio Rome Beauty belt. It was fertilized and sprayed fairly well, but practically no attention was given to pruning except to occasionally cut off broken, diseased and dead limbs. The orchard was

about 30 years old and very brushy as Rome Beauty trees get when in full bearing and pruning is neglected. The limbs had matted together to such an extent that light had become a limiting factor in production. During the demonstration the advantages of thinning out such trees was explained. The tree was left with plenty of bearing surface, but open enough so that all the limbs could produce back toward the center of the tree as well as at the ends of the branches.

The demonstration created quite an impression. Nearly everyone looked at the size of the brush pile and concluded that most of the fruiting wood was on the ground. They figure that the tree would do well to live another season, let alone produce a crop. Lively discussions followed with the specialist defending the amount of pruning done and most of the spectators criticizing the amount of cutting. Mr. Knight himself thought the tree almost ruined, but agreed to give the pruned tree and two others adjoining the same care as regards spraying and fertilizing in order to definitely measure the result on the crop.

Early in the season Mr. Knight gradually began swinging around to the "more pruning" idea. He noticed that the pruned tree was sprayed much easier and more thoroughly with a saving of spray material. The pruned tree carried its crop more evenly throughout the tree than did the unpruned ones. It was noticed that the fruit sized up better and more uniformly on the pruned tree and carried higher color and better finish at harvest time.

A follow up meeting was held in the fall and the crop of the pruned tree compared with the two adjoining checks with the following results:

	Bushels Yield	Bushels Under 2½ Inches	Bushels 2½ to 3 Inches	Bushels Above 3 Inches
Average of unpruned trees	15	1	8½	5½
Pruned tree	20	½	9	19½

The men were quick to see that not only had the yield been increased by pruning, but that the pruned tree carried apples of higher color and a larger percentage of the large sizes. Mr. Knight and many others were convinced that pruning was something they needed to practice more and wished further help with it.

This feeling led to placing a pruning school in Mr. Knight's orchard that winter and marked the beginning of this type of extension work in Ohio. The school was conducted two days and was well attended. Many large growers brought in with them the men they were employing to prune their orchards. Much interest developed in the work. Mr. Knight's Rome Beauty trees were large and brushy and progress was slow. Most of the men found it difficult to prune over six of these large trees a day.

Instruction was given in pruning both young and bearing trees, but the pruning of the bearing trees occupied most of the time. In handling the work the specialist gave a preliminary discussion followed by a demonstration. This was done for each type of tree worked on. Following this the men were assigned to prune trees of similar type and their work was carefully supervised by the extension specialist and county agent. It was surprising how quickly the men acquired skill when the demonstration was fresh in their minds and supervision was given them whenever it was needed. They developed pruning judgment rapidly and before the session was over felt a considerable degree of confidence in their ability to prune a tree properly.

Following this school Mr. Knight and his men pruned 10 rows across the orchard, a total of 214 trees. The orchard was then made a demonstration and ten rows adjoining containing 202 trees were selected as a check on the pruning for the season. The same spray treatment was given the twenty rows. A slight difference was made in the fertilization treatment only. The pruned trees were given but 3 pounds nitrate of soda while the unpruned were given 5 pounds. Considering the amount of pruning given we felt justified in cutting down the nitrate fed to the pruned trees.

Early in the summer Mr. Knight and nearby growers became much interested in this demonstration. The pruned trees were so much easier to spray that Mr. Knight considered the work worth while, for this reason alone. It soon developed that the pruned block was going to heavily outyield the unpruned block. At harvest time this increase was actually measured.

The comparison follows:

	10 pruned rows 214 trees	10 unpruned rows 202 trees
Yield	498 barrels	241 barrels
Actual Gross Income	$3,285.50	$1,563.00
Cost of Pruning	$115.00	———

As a result of this demonstration which had its beginning in a pruning school many orchards in the vicinity have been pruned. Mr. Knight completed the pruning of all but 30 trees in this 1,200 tree orchard last winter. This year he harvested by far the largest crop the orchard has ever produced. The size, color, and finish on the fruit attracted much attention. His 1,200 Rome Beauty trees packed out 4,700 barrels this fall. Mr. Knight is now completing the pruning of this orchard and expects to go over the entire orchard this winter, doing enough light pruning to keep the trees in proper condition.

The striking results following this pruning school and demonstration were made possible because the trees were old Rome Beauties which had thickened up to such an extent that light had

become a very limiting factor in production. Naturally such outstanding results cannot be hoped for in many orchards, yet in the Southern Ohio Rome Beauty belt there are many orchards responding to pruning in about the same degree. Several pruning schools have been held in this belt and much improvement is noticed where they have been placed. The old traditional idea—"Do not prune Rome Beauty Trees"—is gradually being displaced and the pruning schools are playing no small part in changing this state of mind.

In brief summary then we feel that the pruning school has a real place in the extension work for two big reasons:—First, pruning principles presented by discussion and demonstration become firmly fixed in the average mind by the actual pruning practice following the demonstration. Secondly, the average man goes away from a pruning school feeling able to go back to his own orchard and actually do a better job of pruning. This confidence results in getting a large number of trees pruned rather well.

Permanent Demonstration Vineyards in California

By FREDERIC T. BIOLETTI, *University of California, Berkeley, Calif.*

THE function of the extension activities of a College of Agriculture is to get useful agricultural information to the farmers.

The measure of our success is the number of farmers who profit by our activities, the degree to which they profit, and the economy with which we do our work. This economy is determined by the relation between cost and accomplishment.

There are three ways in which we attempt to fulfill our extension function:

1. *By writing:* We publish bulletins and circulars and leaflets and articles. These are distributed by tens of thousands over the state. Some of them reach their mark, but there is a large waste of ammunition.

Where they score a hit, they usually do good. This good, however, is principally indirect. The farmer who is helped most by our publications is he who is interested sufficiently to write to the college for further information, who visits the author for advice regarding the application of the methods to his own particular conditions, or who induces the author to visit his farm and actually "show him how."

To farmers who do not follow this course, our publications occasionally do harm. Farmers may misunderstand an advice or suggestion either through our inability to write clearly or through theirs to read correctly. Moreover, the busy farmer has little time

or opportunity to study general principles carefully and to think out the correct applications for his own particular case.

2. *By talking:* We lecture and talk and read papers in halls and schoolrooms and churches and picnic grounds. Meetings are held where we supply the farmers with a balanced ration of peach pruning, tepary beans, fruit canning, and hog cholera, followed by a light dessert of layer cake, coffee, and apple pie produced locally. All this has social and advertising value, but the solid results in agricultural education are, like those of our publications, principally indirect. Of the farmers who listen with interest to a lecture on an improved system of vine pruning, only those who have time and opportunity to visit the vineyards where the system is being applied obtain much permanent benefit.

Lectures, while more interesting to most farmers than publications, are more ephemeral and therefore less permanently useful. The same farmer will often listen to the same lecture several times in successive years with equal interest in the novel ideas expounded, but without any attempt to apply them. If he does attempt to apply them, he often makes serious mistakes, owing to a failure to exactly grasp the principles, or to a lack of ability to adapt them to his particular problem.

3. *By doing:* We attempt to supplement our written and spoken instruction by "demonstrations," by actually performing the operation we recommend or by showing the results of its application.

In fact, none of our instruction is really assimilated and utilized until there has been a practical demonstration of some kind.

Some rare farmers, after studying a bulletin or circular which they have received by mail or to which they have been directed by a lecturer, are capable of making their own demonstration. They have the time, the experience, and the ability necessary to study the principles involved, and to make the particular applications required for their particular cases. Other farmers who attempt this are only partially successful or fail entirely. Attempted demonstrations by these farmers are likely to throw discredit on perfectly sound methods. Most farmers do not even attempt to use new methods that they hear or read about until they have been given an example by a courageous pioneer. If the pioneer fails, the method falls into a disrepute from which it recovers with difficulty.

It is in order to avoid this danger and to increase the effective instruction of successful demonstration that I have proposed the establishment of permanent demonstration vineyards.

If these demonstration vineyards are to be successful in accomplishing their object, they must be carefully planned and the methods of utilizing them carefully considered. A demonstration vineyard as I conceive it should have certain characteristics which I will list:

1. It should represent something whose utility is well established. All matters of experiment or research should be avoided completely.

2. It should deal with crops or methods of particular interest to actual farmers of the neighborhood. Things new to the district and to exactly similar districts are experimental and should be avoided.

3. The owner or manager should have already proved his belief in the general value of our directions. The most successful cases are likely to be where the owner is his own manager and where he takes an active part in the actual work.

4. Grape growing should be the chief or only occupation of the owner.

5. The owner should be free to follow or accept our advice as he thinks best, but agree to do nothing without consulting us so long as his vineyard is used for demonstration purposes.

6. The agreement to use the vineyard for demonstration purpose should be for an indefinite period and terminable at any time at the option of either the owner or the extension division.

The question of checks or witnesses may be considered here. In any investigation or experiment a contrasting witness is essential. If we want to know the value of a new method we must test it in comparison with the old method carried out by its side.

In the kind of demonstration which I have in mind even the idea of a check or witness should be avoided. It brings in the idea of uncertainty which is confusing to many minds. The position we should take regarding permanent demonstration vineyards is that of experts who are called in by the farmers to show them the best known methods of accomplishing certain objects. We should therefore avoid the introduction of anything of an experimental nature.

We should attempt to demonstrate nothing except what we know to be good and which we believe to be the best known. Methods or varieties or localities whose merits are in doubt are not fit subjects for demonstration.

There will of course be a general comparison made between the demonstration vineyard and the other vineyards in the neighborhood. But this comparison should be left to the growers and not emphasized. If we are as sure of our methods as we should be before we attempt a public demonstration we can leave the comparison safely in the hands of the growers interested.

The best methods of utilizing permanent demonstration vineyards will probably be found in actual practice, but their general character can be anticipated.

A permanent demonstration vineyard, as I conceive it, is a vineyard conducted by the owner for his own purpose, viz., profit. The owner employs the representatives of the extension service, i. e., the farm advisor and a delegate of the viticultural division, to give him expert advice. In payment for this advice he allows the extension division to make use of his vineyard to show or dem-

onstrate to other grape growers what we consider the best known viticultural methods to use under the conditions of his vineyard. These conditions are typical of the district, because the vineyard has been chosen with that fact in view.

How much advice shall be given to the owner will depend on how much he needs. If he is an experienced vine grower, little will be needed except suggestions regarding the newer or more technical methods. If he is inexperienced, the advice will cover almost every detail from the choice of land and variety to the harvesting of the crop.

As with other expert advisers, the owner will be free to discharge his employees whenever he loses confidence in their advice or feels that he cannot afford to pay their fees. On the other hand, the expert advisers will be free to withdraw their special services whenever they believe that the use of the vineyard for demonstration purposes, which constitutes their fees, fails to give sufficient returns for the time and energy expended.

To give an idea of how the advice should be given, I will consider the case of a farmer who desires to grow grapes, but has had no experience in this kind of farming. This is the case where the maximum of supervision will be needed and the case where, perhaps, the maximum of good will be accomplished.

In the first place a consultation is held between the owner and the farm adviser or specialist as to the suitability of the district, location, soil, and water conditions for grapes in general. After this consultation, it may be necessary to refer certain questions to the division of soils or some other division. Such references, however, will be exceptional, as where there is any doubt as to complete suitability, the place ought not to be accepted for our purpose. This consultation will give the representatives of the extension division an opportunity to judge as to whether the owner is likely to make a success of his vineyard and as to whether his personality is likely to make the demonstration to be given there successful.

At this meeting or soon after, the variety to be planted and the general system to be adopted should be settled.

The next step will be for the owner or the farm adviser to make a rough plan of the field to be used, showing its bounds, slopes, directions and relation to roads, buildings, and irrigation systems.

With these data in hand, the viticultural division will draw up a provisional plan showing the location of the vines, avenues, and turning spaces. This plan will be submitted to the owner and modified as may be found necessary until it is satisfactory to both parties to the agreement.

When this is done, the owner will be furnished with directions as detailed as seem necessary regarding the methods of leveling, plowing, and otherwise preparing the soil; the selection, rooting, and care of cuttings, or nursery vines; the laying out of the vineyard; the planting of windbreaks, cover crops, intercalary crops; the putting up of rabbit-proof fences, and any other work which

should be done before the actual planting of the vines. These directions, like all others, will be subject to modification or rejection in consultation with the owner and any irreconcilable difference of opinion on essential points will result in the immediate abandonment of the project.

When the proper time for planting arrives, after all the preliminary work has been done according to agreement, directions will be given as to the best methods of planting.

Later, at every stage where vineyard operations will be needed, appropriate directions will be furnished. These will include, as the vineyard develops, cultivation, irrigation, summer and winter pruning, staking, trellising, control of weeds and diseases, hoeing, tying and harvesting.

The manner of giving these various directions requires consideration. It should include our three methods of instruction. Oral explanations and discussions to convince the owner of the value of the operations, practical demonstrations to show him how to carry them out and printed or typewritten notes to refresh his memory.

This is to give a general idea of how the scheme can be made useful to the owner. It remains to be considered how it can be made useful to the other grape growers of the neighborhood.

This is to be accomplished in two ways.

First, the vineyard will be open to inspection, at convenient times, by any grape growers of the neighborhood. They can look at the vines and decide for themselves whether the results are better than those they are obtaining, or those obtained by different methods in use in the neighborhood.

Second, whenever a practical demonstration showing the actual application of the methods is to be given, the farmers of the neighborhood will be invited to attend. On these occasions the demonstrator will, as much as possible, perform the operations. He will actually plant a number of vines, prune a row or two, hoe, sucker or tie up vines for an hour or more. He will attempt to instruct more by "doing" than by "telling."

Some operations, such as leveling, deep plowing, etc., cannot conveniently be demonstrated in this way, but these are usually operations which are more generally understood and can be applied by anybody who is convinced of their utility. It is the more minute and special operations which are most in need of practical "showing" and most of these lend themselves more easily to actual demonstration.

Among the operations which can be most conveniently used for practical demonstrations and for which there is most need for instruction are pruning, tying, staking, trellising, suckering, sulfuring, spraying, making cuttings, planting, grafting, and callusing.

In a permanent demonstration vineyard handled in this way, we are proceeding by the proper pedagogical method. We are impressing on the mind of the learner the correct thing, done in the correct way. This can be accomplished only in a vineyard which has been correctly handled from the beginning. This is why

demonstrations of this kind are more effective than those given in a vineyard where many mistakes have been made or where other methods, even other good methods, have been followed.

In such a vineyard the demonstrator has to explain his method principally by pointing out how it differs from the method employed on the vines before his hearers. He has to try to give an idea of the correct way by pointing to examples of an incorrect way. This is unsound pedagogically. When the correct way is well impressed on the mind by example and practice, it may be useful to call attention to errors in order to devise means of avoiding or correcting them. If the incorrect method is impressed on the mind first, the difficulty of impressing the correct method is doubled.

Another difficulty encountered in attempting to demonstrate a good method in a vineyard where other methods have been used, is the impossibility or inadvisability of changing. A method may be good, but its introduction impossible where another method has been started. The attempt to introduce it made under such circumstances may in fact do harm.

The demonstrator therefore is placed at a disadvantage in explaining his method. He has first to consider whether his method can be used in the cases before him and next whether it is advisable to use it, and finally how to go about to introduce it—all more or less complicated questions which are often difficult to answer offhand. This leads to delay and apparent hesitation on his part which have an unfavorable effect on his hearers and if followed by the complicated and detailed explanation which is probably needed, when he decides that the new method can and should be introduced, discourages his audience and throws discredit on his method.

These difficulties are avoided if the character and advantages of the recommended system have already been impressed on the minds of the audience.

However, while instruction intended to prevent mistakes is the most important part of our demonstration work, instruction in how to correct mistakes is hardly less important. By a proper arrangement of the work the permanent demonstration vineyard will be useful for this purpose also, but the two kinds of instruction must be given in their proper sequence.

The demonstration of a recommended method in a permanent demonstration vineyard where the method has been planned for and used from the beginning, can be made clear and simple. Few unusual or complicated problems are encountered and the demonstration can be made interesting and useful to a considerable number of growers at the same time. In the course of half a day, 25, 50, or even more growers can be given a very definite idea of the method or of the part of the method being demonstrated. The application shown has been chosen as suited to the conditions of the locality and is of immediate practical interest to the growers present.

To the grower who has not yet planted his vineyard, or whose

vineyard has only just reached the stage to which the method applies, this demonstration may be all that is necessary. To many growers, however, it will suggest numerous difficulties. While a good method is usually simple both in theory and practice there is an infinite number of ways which differ from this method. Growers who already have vineyards will begin to consider how or whether they should introduce the method into their vineyards and will want special directions.

As each vineyard will present its own problems it is difficult and inconvenient to discuss them at the general demonstration. The demonstrator will have difficulty in visualizing the exact condition of the vines which are described to him and for which he is asked to prescribe. Moreover, the discussion of the problems of one grower may have little interest to the other growers present who have their own and different problems.

These difficulties and inconveniences are best avoided by discussing with each grower his special problems in his own vineyard.

My proposal, therefore, is first to confine the general demonstration to the exemplification and explanation of the recommended method with as little reference to other methods as possible. And, second, at the end of each general demonstration to have the demonstrator offer to accompany each grower to his vineyard to give a special demonstration for his particular benefit and for any of his neighbors who care to attend.

Each of these special demonstrations will deal with the particular problems of a particular vineyard, and will be given to the owner after he has had a clear demonstration of what we consider the best method of avoiding or overcoming these problems.

In order to accomplish such a series of demonstrations more than one day will usually be necessary. The general demonstration will require a full half day, but the special demonstrations can often be given at a rate of four or five, or more, per day.

In order to give these demonstrations as effectively and economically as possible they will have to be carefully planned and scheduled in advance. Each method must be demonstrated at the beginning of the season when the operation should be applied. Time and traveling expenses may often be saved by taking advantage of the fact that the vineyards at the extreme south of California are about a month earlier than those of the north. By commencing in Imperial County and gradually working north it will often be possible to demonstrate an operation at the appropriate time in each section on one trip.

Central Fruit Packing Associations as an Extension Project

By R. W. REES, *Cornell University, Ithaca, N. Y.*

THE problems confronting investigators and extension workers in pomology may be divided into two general classes; those which are directly or indirectly related to production and those relating directly or indirectly to the disposal of the crop after it has been produced.

The problems relating to the growth of trees and the production of fruit, were the subject of study long before the passage of the Morrill Act in 1862, which established our colleges of agriculture and brought chemists and botanists into closer relation with farm problems. Passage of the Hatch Act in 1887, which created our agricultural experiment stations gave great impetus to this work. While the progress on many of these production problems has been very slow, the sum total of knowledge gained has been great.

Fruit growers for many years looked with doubt on the findings of scientific men and were reluctant to accept their recommendations regarding orchard practices. To-day it is the rare exception to find a commercial fruit grower who does not depend on his experiment station for information regarding orchard soil management, pruning, spraying, and the various production operations.

The problems concerning the physical handling of the crop and turning it into cash have been the subject of some investigational work. The work on these problems, however, has been conducted for a comparatively short time, and has not been so extensive as that on the problems relative to production. Our real knowledge is very limited regarding the marketing of fruit, and the closely related subjects of grading, packing, storage, and transportation. Fruit growers are asking the station and college workers for an increasing amount of information on these subjects. They expect much more than is available or will be available for years to come.

In 1918 a group of fruit growers, through their county agent, requested the department of pomology to assist them in working out better methods for handling their fruit crop. The only information available was the accumulated commercial experience of the various fruit growing sections of the country. These experiences seemed to indicate the community packing association to standardize grades and conduct collective bargaining to be the best solution. It was necessary to work out a plan of organization to meet local needs and to outline a system of operation which would be practical in the section. The plans were worked out in cooperation with the county agricultural agent.

Community packing associations, as developed in New York,

are cooperative associations incorporated under the state law. They are financed and managed entirely by the membership which is limited to fruit growers. They own or lease buildings in which all fruit produced by the members is graded and packed, the expense of operating being met by a charge on all fruit handled. The fruit is sold on a pool basis, returns to the grower being the average price for variety and grade and size.

The method of procedure in organizing has been for the county agent to call a meeting of fruit growers in communities where there seems to be a real interest in cooperative packing and marketing. At this meeting the extension specialist gives available information as to the results of community packing where it has been practiced, and outlines the general plan for organizing and operating. If there is sufficient interest, a committee of three prominent fruit growers is appointed to make a study of local conditions and report at a second meeting.

The committee makes a canvass of growers who are desirable for membership, and lists the amount of fruit produced by those who desire to become members. After this information is available, the county agent and extension specialist meet the committee and look over buildings which may be bought or leased, help estimate the cost of alterations and equipment, or cost of erecting a new building if this seems more desirable.

A second meeting is called to which are invited only those who have expressed a desire to become members of the association. An informal organization is formed and temporary officers elected. After the detailed report of the committee has been discussed, methods of financing are considered. The usual plan is to divide the expense evenly between the growers regardless of the amount of fruit they produce. Each member gives a demand note to the association for his share of the expense. These notes are taken to the local bank and put up as a collateral security on an association note to secure money for development. As the members retire their notes, they are given a six per cent certificate of indebtedness by the association.

The third meeting of the association is held for the purpose of legal incorporation, adoption of by-laws, and election of permanent officers. After the permanent organization has been formed, it is always important for the extension specialist and the county agent to meet with the executive committee a number of times to give information regarding equipment, alterations or erection of the building, working out of floor plans, and to encourage the committee to have everything ready by the time fruit should be packed. Visits must be made to the packing house from time to time during the packing season to discuss packing operations with the foreman.

The most important forward step in community packing house development during the past season has been the formation of a central association with a membership made up of twenty-one local associations. The central is an incorporated association organized and managed on practically the same basis as the local

associations. Each local has one representative on the board of directors, and the executive committee is made up of one director from each of the four counties. The management is vested in the executive committee and a general manager.

The central owns the brands under which all fruit is packed and sold. It makes rules regarding grading and packing, which are enforced by inspectors who make daily visits to the houses. The central association has played a very important part in transportation problems, especially during the car shortage and in pressing "damage in transit" claims. In the purchase of supplies and equipment a great saving has been effected by pooling orders. Cold storage space has been secured for all locals this season, when many independent growers and packers were unable to obtain space No attempt has been made toward central selling, but the central association has been active in passing trade information among the locals and has helped them open up new markets. It seems very probable that next year the central will put in a sales and advertising department, and will sell the fruit packed by all member associations.

The general manager and the executive committee of the central association, during the first season of operation, have called on the department of pomology for much advice and assistance. The association is rapidly becoming firmly established and will soon be able to meet its problems, and the demands on the department will decrease. The general manager is working in close cooperation with the extension specialist and he is giving freely of information gained by his experience. This information is of great value in organizing and equipping newly formed locals.

Briefly, the benefits growers claim to have derived from the development of the central packing project are:

1. Relief from grading and packing troubles, allowing them to concentrate their efforts on harvesting the crop.
2. A better quality pack than when put up by individuals.
3. A decreased cost in packing the crop.
4. Assurance of a sufficient number of packages and adequate cold storage space.
5. Better transportation service.
6. Relatively better prices due to a wider distribution and the opening up of new markets.
7. A strong organization to help in working out the larger commercial problems beyond the scope of individual growers.

The project on community packing houses was taken up in 1918. That year six were organized and operated. In 1919 seven were added to the list. The past season twelve were added, making a total of twenty-five, twenty-one of which were federated in a central association. Six others were organized, but too late in the season to operate on the 1920 crop. Applications are now on file from more than twenty communities which desire meetings during the winter to consider the advisability of organizing com-

munity packing associations. It is interesting to note that all of the associations formed are operating smoothly, and in a total membership of over 500 not a single man has withdrawn.

A Demonstration Community Packing House as an Extension Activity

By H. S. VANDERVORT, *University of West Virginia, Morgantown, W. Va.*

THERE has been great need for a satisfactory method of demonstrating and teaching how to handle the grading and packing of the large apple crops in the Shenandoah apple section. The matter has been discussed at most every fruit growers' meeting held in the eastern apple district of West Virginia. It was thought some progress was made a few years ago when an apple packing law was passed, but this law became a dead letter because of lack of interpretation and enforcement. The growers continued to put up their own packs which varied from the poorest to the best, and both the growers and consumers continued to suffer loss because of lack of standardization. At the meeting of the West Virginia Horticultural Society in 1918, definite steps were taken to work out a plan of procedure to remedy this condition. At this meeting a committee was appointed to embody the ideas of those who had studied the problem into a bill to be presented to the legislature at their 1919 session, requesting material aid on this important problem.

This committee was successful in securing from the legislature an appropriation of $25,000 to be used to erect a fruit packing and storage house to demonstrate and teach the best method of packing fruit. The bill provided that the plant should be located in the principal fruit producing section of the state and be operated by the College of Agriculture of the West Virginia University. An additional $4,000 was provided for salary of superintendent and instructors in operating the plant for the 1920 season.

The plant was located by a committee named in the bill composed of Dean of the Agricultural College, Horticulturist of the Experiment Station, President of the State Horticultural Society, Horticultural Committeeman of the State Farm Bureau Federation, and the Commissioner of Agriculture. A number of locations were proposed and after going over all of them thoroughly it was decided that Inwood, which is located on the Pennsylvania Railroad in the heart of one of the largest apple producing sections in the Shenandoah Valley, offered the best opportunity to make the plant a success. The attitude of the growers here was progressive and there was no lack of fruit to be packed, as there

are approximately 100,000 barrels of apples shipped from Inwood each year.

The next step was to draw plans for a packing and storage house, keeping in mind especially the apple packing feature, as this seemed to be the greatest need. Before doing this, horticultural extension specialist, R. R. Legge, visited a large number of the best apple packing plants in New York, Pennsylvania, Maryland, Virginia, and West Virginia and gathered all the information possible concerning construction and equipment of such a plant. This information and what could be secured from the United States Department of Agriclture and every other source at hand, was used in drawing the plans and providing equipment for the Inwood Plant.

The packing house is so constructed as to reduce to a minimum the unnecessary handling of fruit so as to avoid bruising and to reduce labor cost. The apples are placed in bushel lug boxes by the pickers in the orchard, then hauled by trucks to the receiving platform of the packing house, where the driver receives a receipt showing the variety, grower's number, and number of boxes delivered. The apples are then placed on the receiving belts and start on their journey over the sorting tables and sizers. The culls and canners being taken out first are carried by motor-driven conveyors to elevated bins, from which they can be emptied directly into the cars. The barrels are coopered and labeled in the second story of the packing house and lowered through chutes convenient to the packers. The barrels are faced, filled, and headed, and after being stamped with the variety name, grade, size, and grower's number, are started on the gravity roller conveyor to the storage house or direct to the railroad car.

Much time was spent in working out the present plan of operation which is briefly as follows: The Extension Division represents the state and employs a superintendent, who at present is Mr. H. W. Prettyman, a graduate who specialized in horticulture at the University of West Virginia. The superintendent has complete charge of the plant and directs its operation. Since the Extension Division is interested in the educational features of the plant, it was found advisable to promote the organization of the Inwood Fruit Growers' Club of the Berkeley County Farm Bureau to handle the commercial end of the business. The club furnishes the apples to the plant and thus makes it possible to teach and demonstrate apple packing and grading to students who actually do the work in a plant handling apples in commercial quantities. The actual cost of packing is borne by the grower whose apples are packed. The club also pooled its apples as to varieties and grades and sold cooperatively.

The club realized the advantage of having a distinctive brand so they adopted the "Johnny Appleseed Brand" and all packed apples are sold under this trade name. An attractive barrel label bearing the brand, name of the club, and a statement by whom packed, is placed on each barrel. This feature has proved of great value to the club. Arrangements were made whereby a well-known

sales agency placed a man at the plant who sold all the apples f. o. b.

A number which is used to designate his fruit is given each grower at the beginning of the season. This number accompanies every lot of fruit through the packing house and finally each barrel bears the number of the grower who furnished the fruit. A record is kept so that each grower knows just how much of his fruit of a certain variety was packed in the different grades. These records are also kept so as to show just how much of each variety and grade of each grower is placed in a car. Thus settlement is made with each grower on the basis of the apples he has in each car.

The primary objects of the packing house are to demonstrate and teach the best method of packing, and train students for packing house managers. A large number visited the plant this past season to get ideas about construction and management. One community packing house has already been placed in operation much after the plan of the Inwood plant. For those who could spend a week at the plant a series of one week courses have been arranged, taking up some special part of the work each day. The first day is spent by the student stacking barrels, putting in the barrel heads, and labeling them. He makes a general inspection of the plant, notes how fruit is received when it arrives from the various orchards and what record is made of it. The second day he sorts apples and picks "facers" for barrels or baskets. The third day is either devoted to putting lids on baskets or heads in the finished barrels. The fourth day he "faces" barrels or "finishes" baskets, learning what an important part the finished package plays towards selling. He turns to bookkeeping on the fifth day as it relates to the packing floor, checks the fruit as it comes in and also helps recheck it as to grade. He checks the fruit into the car when loading begins and learns the various other records of operation that must be kept. The sixth and last day is devoted to the general scheme of operation, particularly as to how the work of cooperative fruit growers' club is carried on and how the club does business with the company that markets the product.

A single year's operation of a new enterprise of this kind is not sufficient to justify one in drawing any definite conclusions, yet a few opinions which have been expressed may be helpful to others attempting this kind of project.

The plant gave an opportunity for the Bureau of Markets, United States Department of Agriculture, to try out the federal inspection at point of origin for which the producers have been clamoring for several years. The federal inspector, representing the Bureau of Markets, and a state inspector, representing the State Department of Agriculture, certified that the apples were packed according to the West Virginia apple packing law. The records show that of the one hundred and eight cars shipped from the plant only one car was reduced in price and this on account of the presence of "specked scab" which developed in transit, while out of twenty-nine cars of orchard pack which were put up

by the grocers themselves and sold through the sales agency, one was flatly rejected and reductions of from twenty-five cents to one dollar and twenty-five cents per barrel had to be made on several others.

It is the opinion of a number of the growers and others in close touch with the operation of the packing house that the requirements for the grades designated in the apple packing law are possibly too high as they require too much good fruit to go as "canners" or as "unclassified." It is also the opinion of many that grades now designated as "A" and "B" should be given a name rather than letters or figures. There would then not be such a tendency to put most everything into the "A" grade because the market thinks "A" grade or No. 1 is O. K. and likewise is of the opinion that there is something seriously wrong with "B" grade or the No. 2 pack.

The strict grading and careful records kept, showing the percentage of culls and canners, has been a revelation to many of the growers. These records gave the grower an opportunity to check up on himself and see just what kind of fruit he was producing. It was found by the superintendent that wherever there was a large percentage of culls it was nearly always due to faulty spraying practice. The grower either failed to get the right materials, had them improperly mixed, improperly applied, or else did not make a sufficient number of applications. This is valuable information for the Extension Division for it shows, as many have believed, that the commercial growers as a rule do very poor spraying. In other words it was demonstrated to the growers themselves that one thing they needed was to pay more attention to spraying.

It might be well to mention in conclusion, that it is the belief of many that West Virginia attempted to construct too large a plant for the size of the appropriation, especially since the plant was built during a time of high and rapidly increasing cost of labor and materials. This increased cost made it necessary for the local growers to assist financially in construction in order to get the plant going without an additional appropriation.

Some are also of the opinion that the storage house in connection with the plant is not advisable as this part of the building represents about half the expense of construction and maintenance. In other words, the cost of such a plant should be within the reach of the average group of fruit growers and thus be a practical demonstration showing the growers how to do a thing which is possible and advisable under their own conditions.

New Interest in Iowa Home Orchards

By H. E. NICHOLS, *Iowa State College, Ames, Iowa*

THE small orchards scattered on almost every farm in the Middle West offer a large problem to fruit extension specialists. The majority of these farm orchards have received no care for years and are not producing enough fruit for the use of the farm family. All through the Middle West farm orchards are dying out and very few are being planted to take their places. As a result, many farmers are forced either to do without fruit or pay high prices for it, even when they have an orchard within a stone's throw of their homes.

Iowa has a very large number of neglected farm orchards, which vary in size from a few trees up to seven or eight acres. In general the commercial orchards are scattered through the southern half of the state, but they do not produce much more than enough to supply the local demands. The small home orchards are usually made up of many varieties of apples and several varieties each of cherries, plums and pears. In many cases the varieties are not commercial sorts, and many are summer or fall kinds. The trees have never received much care, and as a result, in a good fruit year, the local markets are glutted with a very low grade of wormy, scabby fruit.

This was the situation ten years ago when extension work along fruit lines was first started in Iowa. It was soon decided that the main efforts of the extension fruit specialists should be put on the farm home orchards rather than on the commercial orchards. Two major projects were outlined and these have had considerable influence in getting the owners of these small orchards to prune and spray. These lines of work are known as the Summer Spraying Demonstration and the Dual Orchard and Poultry Demonstration Projects. The latter project, by combining two lines of work has proven very popular. In 1920 the Dual Demonstrations were given in more counties of the state than any other project put out by the Extension Department. Four teams, consisting of a poultry man and an orchard man, during the months of February and March, put on demonstrations in 80 of the 99 counties of the state. There were held 292 meetings which were attended by a total of 6,416 people, an average attendance of 22 per meeting. The cost to the state and local people was an average of 16.5 cents per person attending the demonstrations.

These demonstrations are made as practical as possible. Two days are spent in each county. The county agricultural agents schedule the meetings where there has been a call for such work. Usually two meetings a day are held; one in the forenoon and the other in the afternoon. The meetings are held right on the farm where there is an orchard and a flock of chickens. The

orchard man usually starts off by pruning grape vines and raspberries. Then he takes up pruning young trees and later the pruning of old bearing trees. After getting started on a large tree he sends the crowd over to the poultry house, where poultry house construction, diseases and feeding are discussed. By the time the crowd gets back to the orchard, the tree is pruned. After discussing pruning, the subject of spraying is taken up and demonstrated as much as possible by samples of spray materials and spray equipment which are carried by the demonstrator. This work is carried on at the time of year when the farmers can get out in their orchards and prune them and order spray pumps and materials for the coming season.

Up to a few years ago, very few farmers believed that it paid, or that it was necessary, to spray their trees. Even yet, there are many who are skeptical, but they are being converted rapidly. The way to convert the average Iowa farmer to spraying is to show him. All of the "Show mes" do not live in Missouri.

The summer spraying demonstration work was started in 1913 for this purpose. Even before there were many county agents in the state, this work was carried on quite successfully. Since the county agent has seen the value of this work there has been more call for it than can be filled.

The summer demonstration is quite similar to that carried on in many other states, but differs in that it is usually held only one year in a given orchard. In choosing the demonstration orchard, one is selected in a community where there is a need for the work and where the owner is willing to cooperate in making it a success. If the orchard is a large one a certain block is set aside as the demonstration block and it is sprayed by the specialist himself. The owner furnishes the spray pump, spray materials, helps with the work, and pays half of the traveling expense of the demonstrator. The specialist helps apply each of the four sprays, spending, if necessary two days at each place. Each spray on the schedule is advertised and people come in to find out about the work. At the first spray, check trees are picked out and left unsprayed during the season. Usually the trees with the largest number of fruit buds are chosen. Careful records are kept of each spraying as to the time required, the amount of spray material used and the condition of the fruit. At harvest time the crop from a sprayed and unsprayed tree is picked and sorted and a large meeting advertised and held in the orchard. The fruit from both trees is graded as to clean, wormy and scabby fruit, so that the people can see the actual result obtained.

These demonstrations, carried on now for eight years, have had a great influence in getting the farm orchards in Iowa sprayed.

During the season of 1920 orchards in 16 counties of the state were sprayed under this project. Several others were started, but had to be dropped as no fruit set. It is the plan in such cases to go back the next year and carry the work to completion.

In 1920 the following results were obtained in these 19 orchards.

AVERAGE RESULTS FROM 19 SPRAYED AND 19 UNSPRAYED APPLE TREES

	Yield in Bushels	Per Cent Clean	Per Cent Scab	Per Cent Wormy	Gallons of spray used per tree	Cost			
						Materials	Labor	Use of outfit	Total
Sprayed 4 times	6.21	66.6	7.7	*27	13	$.246	$.442	$.052	$.74
Not Sprayed ...	3.1	12.3	31 5	70	0	.0	.0	.0	.0

*Mostly late second brood codling moth injury

The average age of trees is 19 years. The average valuation of sprayed tree producing 6.21 bushels at $2.00 per bushel is $12.42. The average valuation of unsprayed tree producing 3.1 bushels at $1.00 per bushel is $3.10. The return from spraying per tree is $9.32. The average cost of spraying is 74 cents. The net gain of sprayed over unsprayed trees is $8.58.

A total of 1,752 trees were sprayed in these 19 orchards. These trees at $8.58 per tree give a total crop value of $15,032.16 over and above cost of spraying.

These two lines of work carried on for the past 8 years have had a great influence in getting farm orchards sprayed, but they have not been the only factors. The farm bureau movement and the Iowa Fruit Growers' Association have been very important in aiding this movement for better fruit on our Iowa farms. But before explaining these two movements it might be well to see how much interest has been aroused among the Iowa farmers along the line of spraying.

In 1919, 86 of the 100 county agents in Iowa reported that before the establishment of the farm bureau in their respective counties a total of 419 orchards, an average of 4.9 per county, were sprayed. This in most cases was about the year 1917. In 1919, 2,342 orchards were sprayed, an increase of 459 per cent in about 2 to 3 years. They estimated that 4,109 orchards would be sprayed in 1920, an average of 48 per county. This estimate really proved to be low. From present indications it appears that there will be twice as many orchards sprayed in 1921 as there were in 1920. There are about 54,000 orchards in Iowa, so many are still neglected, but the above figures will show that the Iowa farmer is awakening to the fact that he must spray if he expects to have any fruit at all.

The above figures show that the county agents of the state have been a great influence for more and better fruit. There are many agents who do not take an interest in the orchard and in their counties little has been accomplished. Some of these agents, however, after seeing the results of some of the demonstration orchards have become enthusiastic boosters and are getting wonderful results.

At the present time there are comparatively few farmers in the

state who do not realize that spraying pays. The one big problem that they have is to find the time to do this work. Many county agents are helping them solve this problem by organizing spray rings. This idea is rapidly developing and some agents have had considerable success. This method of organization has been in operation only two seasons in Iowa. In 1919 there was one large spray ring, and perhaps several smaller ones where three or four neighbors cooperated in buying a hand barrel outfit. In 1920, 26 county agents reported a total of 137 spray rings in operation in their counties. Six hundred and fifty-seven farmers were having their orchards sprayed in this manner. The present indications are that in 1921 many more rings will be organized.

Mr. W. O. Brandt, County Agent in Benton County has done more in organizing spray rings than any other agents. In 1919 his farm bureau bought a power outfit and sprayed about 20 farm orchards scattered over a distance of 90 miles. These sprays were applied at an average cost of 74 cents per tree for the season. These sprayed orchards were the only ones in the county that produced any fruit. On the strength of this work 15 rings were organized in 1920. Each ring contained from 15 to 23 orchards, averaging 35 trees. Power outfits were purchased for each ring and a man hired to run each machine. The rings covered a circuit of from 18 to 33 miles. A total of 311 orchards, or about 12,000 trees, were sprayed 3 and 4 times. Eighty-four of the 311 orchard owners reported an average cost of $18.63 for the spraying of their orchards and the average value of the fruit produced was $121.20 per orchard. Mr. Brant estimated that about $30,000 worth of fruit was produced over and above the cost of production.

To help further this work, $150 in premium money was offered at the county fair for the best displays of fruit produced in the spray ring orchards. The managers of the various rings went around and collected the fruit from the different orchards and displayed it. Over 1,500 plates were on exhibition, which required two days' work for judging.

With the rapid spread of this method of cooperative spraying in Iowa the Extension Department is offering service to the county agents in spray ring organization. The spray rings have so far proven a success and seem to be the answer to the often-heard objection, "I'm too busy to spray." They must be organized, however, on a sound basis if they are expected to remain a complete success.

What little success has been secured in farm orchard spraying work never could have been achieved without the help of the Iowa Fruit Growers' Association. This is a coperative buying organization made up of fruit and vegetable growers and farmers. Through it any member can purchase any amount of spray materials, spray outfits, pruning tools, and harvesting equipment at very little above wholesale cost. This Association has been doing business since 1913. It has grown from 17 charter members in 1913 to 1,053 in 1920. This last year over $70,000 worth of supplies were sold. The small grower is able to get his orchard

supplies nearly as cheap as the large grower. For over three years this association was connected with the Extension Department, but since April 1, 1920, has been connected with the secretary's office of the Iowa State Horticultural Society. The association has been practically doubling its membership and business each year for the past three years.

With these three organizations behind this movement, the day is not far distant when a very large share of our Iowa farm orchards will be properly cared for. The county agents need the extension specialists to help them instruct the farmers as to the best methods of caring for the farm orchards and both need the Iowa Fruit Growers' Association to make it easy and cheap for the farmers to start spraying, and this association needs the men in the field to help boost their membership and business. Cooperation is accomplishing many wonderful results these days, and if properly directed will go a long way towards increasing the production of more and better fruit on the farms of the Middle West.

Extension Work in Fruit Growing in Nebraska

By E. H Hoppert, *University of Nebraska, Lincoln, Neb.*

COMMERCIAL fruit growing in Nebraska is confined largely to apple and grape growing along the Missouri River. The vineyards are found bordering Omaha, Florence, Peru and Brownville; the orchards are more or less scattered about in the four or five counties bordering the river. A very small proportion of Nebraska's rural population is interested in the commercial phase of fruit growing. The remainder of the state, however, is, or perhaps more accurately, should be, interested in growing fruit for home use. Until commercial fruit growing becomes more general in Eastern Nebraska the extension specialist's time will be devoted largely to home orchard problems.

The main problems in home orcharding are the caring for bearing orchards and the planting and caring for new home orchards.

The Bearing Home Orchard

In the eastern half of Nebraska only a few of the hundreds of orchards planted 20 to 30 years ago are still alive and bearing crops. Neglect, dry weather and disease have taken their toll as in most other states. To encourage better care of home orchards and to promote further planting, it will be necessary to prove conclusively that those which are still alive can, by proper care, be made to pay dividends. The methods as employed in Nebraska are several:

Pruning Demonstrations

The specialist cooperating with the county agents of the state arranges for pruning demonstrations during the winter months, December to April. At these demonstrations the matter of pruning bearing trees is emphasized. Proper and improper tools are shown. The specialist prunes a tree or two showing the method of making cuts, painting wounds, bracing weak trees, etc. Then some of the men in the audience are requested to try their skill. Thereafter the matter of shaping young trees, the training of grape vines and pruning of small fruits, are discussed and demonstrated. Finally a discussion of spraying is given, charts being used to show the need for spraying, life histories of insects and diseases, cost of spraying, etc. Usually, literature discussing these matters is distributed.

Spraying Demonstrations

Spraying demonstrations are given during March, April and May, either alone or in combination with pruning demonstrations. The when and why of spraying are explained by charts and the how by actual demonstrations. Points of interest such as costs, benefits derived, desirable equipment, etc., are brought out during the discussion.

Demonstration Orchards

In addition to pruning and spraying demonstrations it will be possible for the specialist to give personal supervision to a small number of orchards in cooperation with the county agents and the orchard owner. The object of this type of extension work is to make sure that the proper treatment be given the orchards and that fairly accurate records be kept of costs and proceeds. In the past two years another type of demonstration orchard was tried. To the county agent was given the responsibility of carrying out the work. But in most cases the county agent was extremely busy with other types of work at spraying time and the latter was forced into the background. It follows that the results are not entirely satisfactory. For example, in one county the orchards were sprayed only at the time the petals fell, instead of four times as was advised. In this type of demonstration the specialist spends a day at pruning with the orchard owner to make certain that the owner has a proper understanding of the work. The owner is expected to finish the job and he furnishes sprayer and spray materials. At spraying time the specialist holds a meeting at the orchard and then sprays all the trees except two or three which are left as a check. It is impossible for the specialist to properly handle more than 8 or 10 such orchards. At harvest time meetings are held at the various orchards to note results.

Meetings Other Than Demonstrations

During severe weather schoolhouse meetings are frequently held. Such practices as top working, grafting, and the pruning of

grapes, small fruits and young fruit trees are demonstrated. Orchard management is discussed and shown if possible on lantern slides.

Timely Articles

The specialist prepares timely articles on pruning, spraying, and other orchard practices for use by the county agent in his news notes to the papers or in his farm bureau paper.

Exhibits at Fairs

In cooperation with county agents exhibits are arranged at county fairs showing results from demonstration orchards if there are such in the county. For example, the number of culls, wormy and diseased fruits, and the sound first grade fruit from the sprayed trees, are compared with the product from the check trees similarly sorted. Another fair feature that is valuable in disseminating useful information is the extension tent. There are three such tents 30 x 40 feet in size each of which is sent to 6 or 7 county fairs a year. These tents contain exhibits of educational value from the various subject matter departments as prepared by the extension specialist in those departments. One year the pomology exhibit consisted of fruit from sprayed and unsprayed trees; another year of pruning tools, good, bad, and indifferent with specimens showing proper and improper cuts; another year desirable spray machinery and accessories were shown together with pictures and specimens of common insect and fungous pests and materials and methods used in their control.

Another feature of fair work that lends itself to the extension horticultural practice is the judging of fruit exhibits. The extension Service of the University is asked to furnish judges for from forty to forty-five fairs a year. The judging of exhibits is made educational by explaining the reasons for decisions. In the judging of fruit this point is not nearly as important as is the case with live stock, yet it is worthy of mention.

Establishing New Home Orchards

In the last few decades a large majority of the old home orchards have died out. At the present time considerable interest is shown in planting new orchards, mainly because fruit is high priced and rather difficult to obtain at all seasons of the year. That the average farmer is not sufficiently acquainted with the planning and planting of the farm orchard is manifested by past attempts. The most common mistakes found are, too many trees, poorly adapted varieties, plainting too close, and neglect.

The extension specialist with the aid of the county agents is trying to prevent the repetition of these mistakes in a number of ways.

1st. The subject of orchard planting is discussed at the pruning demonstrations. Charts showing model orchards are shown. Lists of desirable varieties are distributed to interested parties. The training of young trees, vines, etc., is demonstrated.

2nd. Blue prints of model orchards showing spacing and arrangement of trees and the number of the different fruit trees needed for home use are sent to the county agents. These prints, together with a list of desirable varieties are tacked up in the county agent's office.

3rd. Talks at schoolhouse meetings, etc., with lantern slides and charts.

4th. Articles and publications. An extension bulletin embodying various phases of planning and planting is being distributed.

5th. Establishing model home orchard demonstrations.

In counties where an interest is being shown in orchard planting, model home orchard demonstrations can be used to good advantage. In several cases these have been established in conjunction with model farmstead demonstrations. The specialist in cooperation with the county agent helps in selecting the site, suitable varieties and arrangement. A pruning demonstration is given at planting time. Each succeeding year this orchard is used for such work as is needed; namely to demonstrate inter cropping, mulching strawberries, pruning grapes, etc.

6th. Orchard news service. Arrangements have been made to secure from the larger nurseries in the state, a list of the purchasers of home orchards. It is the aim of the extension specialist to file these names according to age of orchards and sections requiring special treatments. Circular letters will be prepared for the various lists, calling attention to the needs of the orchard at different seasons. It is hoped that this method will tend to promote more intelligent and widespread care of home orchards and satisfactory dividends on the investment.

7th. Exhibits at fairs.

This year the horticultural extension exhibit accompanying the extension service tents consisted of a model home orchard. The trees and other fruit plants shown were made of green crepe paper fastened to the bottom of a wood case, 3 feet by six feet in size.

Other problems of local interest but yet deserving of some attention are the renovation of vineyards, the renovation of the old commercial orchard, planting windbreaks, planning the new commercial orchard, home storage of apples, and boys' and girls' club work in fruit growing. It is planned to have several straw berry clubs and several grape clubs in 1921.

Extension Work in Horticultural Manufactures in Massachusetts

By W. R. COLE, *Agricultural College, Amherst, Mass.*

THE project upon which the Department of Horticultural Manufactures at Massachusetts Agricultural College is built, includes every line of preservation of food products except the dairy interests. It embraces the storage of all food products either in raw or manufactured state, in common or cold storage by producer or consumer; the preservation of food products by cooking either for home use or for market; the manufacture of food products from raw or manufactured material.

The department was organized three years ago and an extension specialist appointed in May, 1919. The project under which he works reads as follows:

FOOD PRESERVATION

This project has to do with the preservation of fresh fruit and vegetables through storage and with the manufacture of their products. It is offered in six parts:

I. Farm storage
II. Home storage
III. Cooperative storage by producers or consumers.
IV. By-products manufacturing.
V. Home and farm manufactures.
VI. Fruit as food.

Objects:

a. To equalize market possibilities and to provide a profitable market for cull and surplus crops.
b. To encourage production and teach thrift through the conservation of fresh products and the profitable utilization of culls and surplus crops.
c. To increase the supply of food and to educate the public to the value of fruit as a food.
d. To promote the health of the community by lengthening the season of fresh fruits and vegetables.

Procedure:

1. By lectures, demonstrations, collective conferences and the extension schools. Acquaint growers and consumers with the benefits of food preservation through storage of fresh fruits and vegetables, and the marketing of

culls and waste and surplus crops by means of manufactured products.

2. By giving special individual instruction and assistance in the construction, equipment and operation of storage plants and factories and of cool-rooms in the home cellar.
3. Stimulate public demand for farm and cooperatively manufactured products by lectures, newspaper publicity and exhibits at fairs and other public gatherings.
4. Encourage the use of fruit as food by means of lectures, newspaper and magazine articles and demonstrations showing the healthfulness of fruit, its sugar content in various forms and its desirability in the diet.

While the project carries but six subdivisions it has been deemed wise to make reports under nine heads and the same outline will be followed in this paper.

I. Farm storage.
II. Home storage.
III. By-products manufacture.
IV. Fruit as food.
V. Home food preservation.
VI. Cooperative storage.
VII. Fairs and exhibits.
VIII. Extension schools.
IX. By-products and storage investigations.

Farm Storage

This sub-project covers the field of storage of fruit and vegetables by producers who desire to hold for a better market situation. The specialist has made a total of 195 farm and group visits reaching a total of 589 owners and managers of orchards and farms. These have been in the nature of special help to individuals or groups and the figures do not include those who have been present at extension schools or other large meetings. As a result of this work, more than 100 storage cellars have been improved or created in the apple and vegetable growing districts of the state. Many of these storages have been developed from old cellar holes or from unused barn cellars. Instances may be cited where the owner has gained the entire cost of putting in these cellars from the increase in return on one season's crop.

Home Storage

The work under this sub-project has been quite largely educational by means of demonstrations in constructing full-sized home cellar cool rooms, by distribution of mimeographed material, by bulletins and by news letter releases to the press. Four full-size rooms have been built reaching 120 people during the construction

work and an estimated number of 1,000 since being built. Two of these were built at fairs and were on exhibition during the fair dates. Lectures illustrated by slides, models and charts have been given in eight places to an attendance of 250 persons. Mimeographed material to the extent of 10,000 pieces has been distributed and 1,500 bulletins sent out.

By-products Manufacture

This includes manufacturing plants under cooperative organization, farm factories, and kitchen factories. Three cooperative plants have been organized and a fourth is in its first stages. Assistance in organization, equipment and methods, has been extended to 50 farm and kitchen factories. These different activities are using cull apples to a large extent and a very complete line of fruits and vegetables is being handled in many of them. The cooperative organizations are primarily apple by-products plants. The farm and kitchen factories are putting out a more or less complete line of fruit and vegetable products such as canned goods, jams, jellies, butters, pickles, etc. This sub-project has called for 107 visits reaching 504 persons.

Fruit As Food

This subject has been handled by means of mimeographed material, charts, news letters, and exhibit material. Five thousand sheets of mimeographed material have been distributed and exhibit material consisting of charts and cases showing food values by cane sugar equivalents has been used at seven fairs and exhibits.

Home Food Preservation

The work under this sub-project consists of lectures and demonstrations to home economics teachers, home demonstration agents and groups of housewives. Additional effort has lain in the distribution of mimeographed material, bulletins and fair exhibits. A total of 76 demonstrations and lectures has been given reaching 1,386 people. Five thousand sheets of mimeographed material have been distributed and 2,000 bulletins sent out. In addition to the above many individual inquiries have been handled either by mail or in person.

Cooperative Storage

This problem has been approached from two sides. One is the group of producers desiring to hold cooperatively for better markets, and the other is groups of consumers desiring to buy in quantity and hold for a season's consumption. The project is just getting started and but one group in each case is at present organized. Several owners or managers of industrial plants are interesting themselves in the second phase of the question and several groups of producers are interested in the first. It is recognized as one of the most important of the questions confronting the de-

partment and will undoubtedly call for a greater degree of attention as time goes on

Fairs and Exhibits

This is one of the best means of putting over the idea of food preservation and its value to the public. The specialist has been in attendance with an exhibit at thirteen fairs for a total of 74 days and has reached 1,536 people by personal contact. An estimated total of 185,250 people has been reached by the fair exhibits. At the Eastern States Exposition, Springfield, Mass., a steam cooker was installed and 6,000 samples of apple butter were made and given away. As a result of these exhibits at the fairs, a mailing list calling for 3,000 copies of bulletins relating to the work of the department was obtained. In general, the exhibits at fairs are made up of subject matter, charts, samples of canned products, jams, jellies, butters, etc., and articles of standard equipment for preservation work.

Extension Schools

The specialist has taken part in five schools with an attendance of 964, lecturing on preservation and storage.

Investigational Work

This takes in the investigation of equipment supplies, packages, the machinery for cold storage plants, elevators and marketing problems for disposing of products of farm factories. It includes a total of 66 visits with 134 contacts.

Summary of Activities

	Visits	Contacts
FARM STORAGE, apple and vegetable	195	589
HOME STORAGE, by consumers	16	483
BY-PRODUCTS MANUFACTURE, by co-operative associations and individuals	107	504
FRUIT AS FOOD, lectures, exhibits, etc.	7	70
CO-OPERATIVE STORAGE, by producers and consumers	10	50
FAIRS AND EXHIBITIONS, subject matter and materials	74	1,536
EXTENSION SCHOOLS	10	964
HOME FOOD PRESERVATION, demonstrations and lectures	76	1,386
INVESTIGATIONAL WORK, equipment and market	66	134
	561	5,716

In addition to the activities listed above, the department has made a survey of the preservation work being done at 35 state institutions with a view to increasing the amount done and assisting in raising the quality of the product.

The work is yet in its infancy and the department is finding it increasingly difficult even now to answer all calls for assistance. Many inquiries are received from outside the state for assistance in individual problems.

More and Better Potatoes

By F. C. GAYLORD, *Purdue University, Lafayette, Ind.*

IT has been our belief that the most effective extension work with the most permanent and definite results, can be accomplished by selecting one or two projects sufficiently large and important to occupy almost all the time of specialists pushing these until the methods recommended become firmly established. The results already secured by following this method have more than justified the soundness of this belief.

In Indiana the potato improvement work seemed to be such a project. This particular crop was selected first since it is one in which almost every farmer of the state is interested. The commercial acreage is largely restricted to definite areas thus making extension work with it a simpler problem. Though this crop is generally planted on the most fertile soils of the state, it has not always proven a profitable one, since the average production for the State of Indiana, over a ten year period, falls below 90 bushels per acre. Nevertheless, we have even in bad years, growers in every portion of the state producing from 150 to 200 bushels per acre. These facts led us to believe that with better cultural practices and more attention to the fundamentals upon which success lies, the crop could be made more universally profitable. Nor have we grounds for fear if annual yields should be decidedly increased, since we have excellent consuming markets in every section of the state. This is forcibly emphasized by the fact that Indiana imports annually for eating purposes alone, more than three thousand cars of potatoes.

Potato extension, like many other projects, usually resolves itself into the presentation of disconnected demonstrations on various phases of potato improvement work, such as seed treatment, fertilization, variety tests, and seed selections. Seldom have these been combined and the work carefully followed during several seasons. To really secure results, every factor essential to large yields of high quality must be considered and given careful attention. To accomplish this with the help of the county agents of the state, a carefully drawn project was written, broad enough to meet the requirements of the work, yet sufficiently definite to indicate just what was to be done. In handling the disease end of the project we have had the active help and cooperation of the Botany Department. This project was started with the largest growers in the commercial sections of the state. Here the county agents called all the potato growers together in each community. At these meetings the possibilities of the crop and a few of the main causes for low yields, were discussed by farmers and representatives of Purdue University. Samples of certified seed of varieties recommended and specimens of a few common and serious potato diseases were shown; Bordeaux making and spray equipment were

discussed and demonstrated. By these meetings a great amount of interest was developed resulting in farmers being anxious to have demonstration fields in their respective communities.

It was left to the county agent to select the commercial grower who would carry on the demonstration in the community. As the result of our experiences we have found that the success or failure of the demonstration rests largely with the type of co-operator secured. He should be a real potato grower, one equipped to do the work thoroughly, one who will follow directions implicitly and one who not only has faith in the work to be performed, but also fully realizes his part in the project.

At the beginning not more than three cooperators were selected in any county. The first work with these men was to go over their seed stock examining it for purity of variety, vigor, trueness to type and freedom from disease. If the seed was unsatisfactory, the farmer was asked to secure selected seed from places we recommended. From practical farm experience and results secured at the Indiana Experiment Station, it seemed best to limit varieties in demonstration fields as well as in the state to Irish Cobbler, Early Ohio and Rural New Yorker. If the seed stock was satisfactory, five bushels were bin selected with which to begin seed plot work the first year. After selecting the seed it was properly stored, treated with corrosive sublimate and finally green sprouted about four weeks before planting time. The first year all the essential operations were performed by the specialists and the county agents, or under our personal supervision. We have found that it does not pay to allow cooperators to treat seed, cut seed, rig up spray apparatus, or mix Bordeaux without supervision the first year.

During the summer the seed plot was rogued twice for varietal mixtures and diseased plants. Usually at the second rogueing a field meeting of those interested was called by the county agent. This proved an excellent place and time to convince the skeptical of the advantages of the methods demonstrated. Before the vines had died, individual hills were selected and five bushels of hill selected seed were saved for the seed plot another year.

By examining scores of storage places and the condition of potatoes therein, we have been convinced that a large part of the seed stock held over in this state loses much of its vitality through poor storage. For this reason we have strongly urged the use of cold storage, cement cellar storage, and outside pit storage. By carefully constructing outside pits using straw and dirt, we have held hundreds of bushels until May 15 without any considerable loss from shrinkage, and without a sign of sprouting.

The twelve demonstration fields carried on during 1919 gave striking results. In many places the yields were doubled. A net increase of a hundred dollars per acre or fifty bushels per acre was secured in one field. In another, yields were increased from fifty to one-hundred per cent, or a gross increase of $130 per acre. Several other fields did equally well, the average increase being

about twenty-five per cent. During 1919 spraying late potatoes with Bordeaux increased yields thirty per cent.

During the winter of 1919-20 the results from demonstration fields were used in different articles written from several angles and a large amount of newspaper publicity given them. Results were also discussed at meetings in counties where fields were located as well as in neighboring counties. It has been found that the old cooperators do not need very much help the second summer.

Results secured during 1920 again demonstrated to the farmers that careful attention to each factor pays. Few of the demonstrators have secured less than 100 bushels per acre and some have reached 250.

In connection with the general work each fall, window displays, potato shows, and exhibits at state fairs, have been used to advertise the results secured in demonstration fields. These exhibits have resulted in securing added interest when featured in the local newspapers.

While the work was going along nicely in commercial regions we wanted to reach the seventy odd counties in which farmers are growing potatoes, but not on a commercial scale. We wanted to get them to standardize on varieties, use better seed,—in a few words to use all the better methods leading to profitable yields. In most of these counties the yields are so low that the crop has not paid expenses. To help correct these conditions, we have outlined a two year and a four year potato club project, under the supervision of the vocational teachers and club leaders of the state. The work is being carried on as a regular club project, following the same general principles as used with the commercial growers. This work has been under the direct supervision of the Club Division, specialists from Horticultural and Botanical Divisions furnishing all technical information on growing and handling the crop.

To further encourage this part of the work we are putting on a Boys' and Girls' Potato Show, held under the auspices of the Indiana Horticultural Society at which more than $600 in cash and trips are being offered to exhibitors.

This potato show will be held in connection with the Farmers' Week program, thus several thousand farmers from all over the state will see what the potato club boys have been able to do by using good seed of the right varieties and following the best cultural practices.

As a result of this club work 35 vocational teachers and county agents have organized potato clubs and are carrying on this regular improvement work. A summary of reports already turned in shows that 201 boys completed the work, growing seventy acres and producing 1,050 bushels of marketable potatoes or an average yield per acre of 150 bushels. The gross returns from those reporting showed $14,248.18 with a net profit of $8,477.00 or an average profit per boy of $42.17. Of all the 201 boys only a few grew less than a hundred bushels per acre.

In connection with this work the Indiana Experiment Station has been for the past three years comparing northern grown certified seed stock with Indiana grown seed. With the building up of selected strains of potatoes in each community through demonstration fields, we have the foundation for certification of our own seed stock if that seems feasible. As a result of work so far we have demonstrated the value of seed selection when carried along with other good cultural practices. There has been a jump in the importation of certified seed from nothing to five cars last year and an increase in interest in better seed and cultural methods.

To briefly summarize, the extension specilalists have spent most of the time during the past two years upon this one project emphasizing every phase of the potato improvement work.

The points emphasized have been: The use of selected seed of standard varieties suitable to Indiana; seed treatment; green sprouting; cutting for wilt; regulating size of seed pieces; preparation and fertilization of soil; planting; spraying and rogueing the field; hill selection and proper storage.

The success of these practices and methods have been so clearly demonstrated that very little help is now needed in the communities where the work has been going on. The future of it lies largely in the hands of the county agents. It is our aim now to turn our attention to the canning tomato crop improvement work and proceed with it in a similar manner.

An Old Disease in a New Place

By W. L. Howard, *Deciduous Fruit Station, Mountain View, Calif.*

THE stone fruits of California constitute the chief agricultural wealth of the state. These fruits, for climatic reasons, have been peculiarly free from brown rot in the past. Since the bulk of the stone fruits of the state is grown under semi-arid conditions, that is, without summer rains, the growers have felt that their peaches, plums, prunes, cherries, and apricots, were not likely to be destroyed by rotting in the summer. Indeed there has been so little rotting of the fruit that even growers who formerly lived in the Southern States or on the Atlantic Coast had almost forgotten there was such a disease as brown rot.

For the past four or five years, however, an increasing number of complaints has been heard from apricot growers located immediately on the coast or along the coastal valleys, that some disease was destroying the blossoms and fruit spurs, the trouble usually showing up at blooming time. Professor R. E. Smith, of the Division of Plant Pathology of the University of California, began an investigation about five years ago, and found that the trouble was due to a fungus which he identified as *Sclerotinia fructigena* and which apparently was the same old brown rot that has for

generations been so destructive to peaches and other stone fruits east of the Mississippi.

The peculiar feature of this outbreak of the brown rot is that it has been confined almost exclusively to the cold, moist region along the coast, or in the vicinity of San Francisco Bay. The disease does most damage in places where frost injury is likely to occur, and least, in this region, in places where air drainage is good and where spring frosts have rarely or never occurred. Of course the atmosphere is quite humid in the region under discussion, but why the fungus seems to have become adapted to spots where low temperatures prevail around blooming time, rather than to warm places is not clear. In the great valleys in the interior of the state, beyond the costal influence, the disease in the form mentioned has rarely occurred.

During the season of 1920 the ravages of the brown rot on the apricot along the coast became so severe that the yield was reduced on the average something like 30 per cent. Unfortunately, the bulk of the apricots are grown along the coast, so the money loss from the disease in a single season ran into millions of dollars. In many orchards the crop was completely destroyed. Many growers were becoming discouraged and considering plans for top-working their trees to other fruits.

In January, 1920, the University of California established at Mountain View an experiment station for the investigation of problems pertaining to deciduous fruits, and the writer was placed in charge. One of the first propects taken up was to find a means of controlling the brown rot in apricots. Sixteen different spray treatments were tried. It was found that the disease could be controlled to within 4 or 5 per cent by a single application of of either lime-sulphur 1 to 10, dry lime-sulphur 12 to 50, or Bordeaux mixture 4-5-50, when trees were sprayed after the fruit buds were noticeably swollen. The nearer the blooming period the sprays were applied the better were the results. Previous to this investigation, the University had been recommending three lime-sulphur sprays, one before the swelling of the buds, another after buds were swollen, and a third after the blossoms had fallen. This program was found to be impractical, as no grower could hope to apply three sprays at the times mentioned, on account of rains and wet ground, which are apt to prevail at that season of the year. Now we know that spraying after the trees are passing out of bloom does very little good, and that spraying before the buds swell is equally unprofitable. Apparently the disease attacks the trees when they are in full bloom.

Crude oil emulsion such as is commonly used in winter against the brown apriocot scale (*Lecanium corni*) gives great promise of being an effective remedy against the brown rot, where spraying is done after the buds begin to swell. A distillate emulsion failed to control the disease, and the same was true of lime whitewash, and of dry sulphur dusted on the trees. The self-boiled lime-sulphur spray such as is commonly used on peaches in the South apparently has a toxic effect on apricots, so it cannot be safely used. One

application of this material was made about the middle of May, when the fruit was half grown, to prevent the ripe fruit from rotting. Apparently it had no effect whatever upon the disease, but it did cause great injury to the fruit, as the development of the latter was completely checked.

The brown rot has not been a serious problem, as regards the rotting of the ripe fruit, it only being necessary to thin the fruit so that the individual specimens do not touch. Apparently this immunity is due to the dryness of the air at or near the ripening period.

The brown rot also attacks peaches and prunes in spring under the same climatic conditions as discussed above for apricots, but so far has done no great harm as regards either bud or blossom injury. In isolated cases, numerous flower clusters of the French prune have been attacked and the twigs sometimes killed, but the ripe fruit rots only rarely. In Sugar prunes the disease apparently seldom attacks the flowers, but it may rot a considerable quantity of the fruit near ripening time unless some hand thinning is practiced, which is not often done with prunes.

This year, for the first time, the brown rot became a serious source of loss to peach growers at ripening time, especially in the Santa Clara Valley, which is near the coast. In only a few cases was the disease observed to have attacked the blossoms. Large quantities of Tuscan Cling peaches rotted in the orchard or in the lug boxes after being transported to the canneries. The losses were much reduced after the cannery officials learned what the disease was and how to practice such sanitary measures as disinfecting the boxes in which the fruit was delivered. These boxes are used over and over again, so that it was possible to steam them each time before returning them to the orchard.

Experiments will be conducted looking toward the control of the brown rot as regards the destruction of ripe fruit. Numerous new tests will also be employed looking toward the control of the disease in its spring form on apricots. More than twenty different sprays and combinations will be used in the spring of 1921 in a commercial orchard leased for the purpose. Several dust sprays, such as dry Bordeaux and sulphur and lime, will be given a trial as possible substitutes for liquids when the latter cannot be used on account of rain or wet soil.. Curculio does not exist in California, so it is unnecessary to make use of arsenate of lead in any of the spraying programs.

Judging a Spray by its Chemical Content

By W. S. Brock and W. A. Ruth, *University of Illinois, Champaign, Ill.*

IF a spray were to be judged solely by its chemical content, particularly of one element, such as copper or sulphur, it is obvious that many of its properties, including all physical properties, would have to be ignored. This is sometimes done, in fact, it seems to be rather the rule in judging such manufactured products as bordeaux mixture pastes and sulphur sprays. It has been applied particularly to dry lime sulphur and will probably be applied in the future to any new sprays that may be introduced. Among the properties that may thus be ignored, the ones of most importance depending upon the spray material, are solubility, rate of decomposition, adhesiveness, absorption of the components of the spray, or its decomposition products, the effect of light, heat and moisture upon the material and upon the relation of the material to the plant, and to the fungus which it is supposed to control. Many other factors not readily apparent must play a part in its efficiency. It is difficult to attribute to any one of this complex of conditions a definite effect which it alone exerts. A change in any one of the factors enumerated might readily effect a change in the behavior of the whole complex. To use simple illustrations from a sligthly different field, it is known that the thermal death point of organisms depends upon the previous history of the organism and upon the hydrogen ion concentration, while the toxicity of any substance depends upon the temperature. These facts have by no means always been recognized generally in the field to which they apply. So far as spray materials are concerned, repeated field trials in the immediate locality in which the results are to be applied, seem to be necessary. They must be carried out under conditions which allow a reasonable shifting in environmental factors, with the consequent changing effectiveness of the spray material. After this has been done it can be said with assurance that 3 pounds, for example, of a tested commercial bordeaux mixture paste of constant composition is the proper strength. It can hardly be said that a certain weight of another bordeaux mixture paste, containing an equal amount of copper is equally effective, unless the physical properties, including the rate of settling, the solubility of the gelatinous preciptate, and a host of other properties, are the same. A case in point is Pickering's Bordeaux paste, made by using lime water instead of milk of lime. This has been judged, from various standpoints, including its copper content, its solubility, and field tests on certain plants against certain fungi, to have twelve times, six times and twice the efficiency of bordeaux mixture of equal copper content.

The successful use of dry lime sulphur in Illinois illustrates my argument against judging a spray material by the single fac-

tor of its content of one element. Dry lime sulphur is a modified lime sulphur. The Sherwin-Williams product is made by adding sugar to lime sulphur to prevent decomposition during drying and evaporating to dryness in a vacuum. Experiments with liquid lime sulphur have shown that a rather definite sulphur content of the diluted lime sulphur spray is necessary to control San Jose scale. The range of concentrations of sulphur over which fungi can be controlled have not been determined definitely, but there is a customary dilution. Because the Sherwin-Williams Company recommends a greater dilution of this new product, judging by the final total sulphur content, the material has been criticised. That this criticism is not justified in Illinois, is indicated by the fact that in five years' tests it has proved as effective in controlling apple fungi, at the low sulphur content recommended by the manufacturers, as liquid lime sulphur at the customary dilution, and in two years' tests in two localities, as effective in controlling San Jose scale as lime sulphur at the necessary dilution (concentration.) The addition of sugar has, seemingly, made this difference in the effect of spray on scale; the variation in strengths of liquid lime sulphur which, it has been shown, may control fungi, does not permit of the assumption of such an effect of the added sugar in controlling scab.

Use of Dust Sprays in California

By W. L. HOWARD, *Deciduous Fruit Station, Mountain View, Calif.*

DUST sprays, used both as fungicides and insecticides, have been in general use in California for many years. Dry sulphur has always been the standard remedy against mildew in grapes, and since the vineyard business of California has always been one of our most important agricultural industries, enormous quantities of sulphur have been used in dusting the vines. In no other instance, however, has a dry spray proved of practical importance in California as a fungicide. There has never been any serious effort to use dry sprays against disease of tree fruits, except possibly to employ dry sulphur against the mildew in apples, and this was always a failure. Wet sprays, it may then be said, are now almost exclusively employed for controlling diseases.

In striking contrast with disease control, splendid success has attended the use of dry sprays against certain insects. One of the first marked successes in this direction was the use of sulphur dust against red spider on almond, peach and prune trees. The dust is applied, usually by means of a hand dusting outfit, after the insects appear in midsummer. It is believed that the killing principle of the spray depends upon the slow volatilization of the sulphur under the heat of the sun, and that it is these slowly liberated fumes that kill the mites.

During the past year or two, another long step has been taken in the use of dust sprays by the discovery of a new insecticide which can be used as a dry spray. The new dusting material consists of a carrier made of kaolin clay, which easily reduces to an almost impalpable powder, to which is added specific quantities of nictotine sulphate (Black Leaf 40). This material, the original brand of which is known as Nicodust, is now available in different strengths, namely 2, 5 and 10 per cent. This spraying material was devised by Prof. R. E. Smith, former head of the Division of Plant Pathology of the College of Agriculture, University of California, as a remedy against leaf aphis of walnuts. It had never before been possible to control this insect on walnut trees, mainly for the reason that the trees were too large to be successfully sprayed with liquids. It often required hours to spray a single tree properly with a liquid, and then the results were far from satisfactory. The job may now be done with 2 per cent Nicodust in a few minutes and secure a very satisfactory kill of the insects.

During the season of 1920 the Deciduous Fruit Station of the University of California found that a 5 per cent Nicodust could be very successfully used in controlling thrips on prunes and pears, as well as on nursery stock. Owing to the fact that Nicodust kills by the rather rapid liberation of the nicotine fumes, it is necessary to apply the material to the trees during the warm part of the day, under California conditions, as the nights and early mornings throughout the spring and most of the summer are apt to be very cool.

The use of the nicotine dust described is being extended as a remedy against various other insects. Strangely enough, it has not been a success against the red spider. This may possibly be due to the fact that the fumes are liberated too rapidly. Apparently, after about three hours all of the nicotine vapors have been completely dissipated, whereas sulphur fumes are liberated more gradually and continue for days.

Arsenical sprays in dust form, as well as certain fungicidal sprays, are now in general use in California, but all of these are reduced to a liquid for spraying purposes. Dry arsenate of lead is now in almost universal use, and a dry form of lime-sulphur is rapidly supplanting the customary liquid lime-sulphur in the principal fruit districts. Dry Bordeaux, which is added to water, is now similarly being used by those who prefer Bordeaux to lime-sulphur, or require it for certain purposes.

Beginning with the season of 1921, the Deciduous Fruit Station will make extensive tests of dust sprays against brown rot. Judging from the results secured by peach growers on the Atlantic Coast, first-class control by dusting is scarcely to be expected. However, if apricot growers, for example, are prevented from spraying with liquids at the proper time on account of rains or wet soil, they would be content with a lower degree of control if this could be secured by some other means, as by the use of a dust. The advantage of the dust will lie in the ability of the grower to get on the land with a lighter spraying outfit and be able to spray

his trees much more quickly. Dusting outfits, as used against thrips in prune orchards for example, are able to cover from 4 to 35 or 40 acres a day, depending upon whether a hand outfit or a gasoline power outfit is used.

Arsenate of lead as a dust has never been used, except in a very small way against such insects as the codling moth, and where it was employed it was not a success. The future development of dry sprays as insecticides seems to lie in the direction of those that give off fumes rather than in the use of arsenicals. What the future holds for dusts as fungicides is problematical. Probably they will always be of only secondary value for the purpose, but even so they would have a place in the fruit grower's program, and might be expected to be highly valued under the special conditions under which they are employed.

Spraying Versus Dusting in Illinois

By W. S. Brock, *University of Illinois, Champaign, Ill.*

ONLY one apple orchard was dusted in Illinois during 1920. There will be none in 1921. This state of affairs is partly due to the advices of our experiment station, but chiefly to the experience of reputable apple growers widely scattered over the apple producing sections. From the advices which come from other states, the Illinois station has taken the stand that we would not condemn the dust method, neither would we recommend it, in the belief that, in the last analysis, the fruit growers would decide the thing. It would appear that a negative decision has been reached.

The one outstanding feature of the four years' work is that of uniform curculio control. In no case has the dust failed to give better control than spraying, which would seem to indicate that at least the material was distributed, a point which has been much discussed. The question of curculio control is conceded.

In 1915 and 1916 the control of codling moth was entirely satisfactory, although no satisfactory conclusions can be drawn from an infestation of 9 per cent on check trees. The total failure in 1917 may be attributed to faulty application, perhaps. If we omit the 1917 results we would have an average infestation of 33 per cent on check and 6 and 12 per cent respectively for the liquid and dust, which does not look so bad from the standpoint of figures in terms of percentage, but would make considerable difference in reckoning apples at $8.00 per barrel.

The most serious indictment against the dust in Illinois is, and has been from the start, its failure to satisfactorily control scab, it being conceded even by the strongest adherents that dusting could not control blotch. A four year average of 82 per cent of scabby fruit is entirely adequate for correct comparisons, and so we have for the liquid 12 per cent of scab, and 41 per cent on

dusted, nearly 3½ times as much. The figures given for codling moth, scab, and curculio are all of the results obtained by the Department of Horticulture. No figures are shown for 1919 and 1920 because no experiments on the dusting of apples were planned after 1918. We, therefore, hold that there is no experimental evidence to show that dusting with sulphur-arsenate of lead powder would be advisable in Illinois.

Evidence other than authoritative experimental data will probably be ruled out of our Society meeting, but we propose to show that reputable commercial fruit growers have tried to use the dust without success. Letters and telegrams from the following well known commercial fruit growers who have owned and operated dusters do not sound encouraging to dust adherents:

From R. A. Simpson, Vincennes, Indiana:[1] " * * * About four years ago we bought a dust spray machine, same to be used in case of emergency. We had the Niagara machine, which worked very nicely, indeed, but the dust was not altogether satisfactory. In the first place it cost more to dust than to use liquid, and in the second place, unless the wind was in one direction during the time we were spraying, the dust did not go in a uniform way * * * * We did not carry on any plot test of the dust compared to the liquid, therefore, cannot say how it compared in efficiency with that of liquid. We did not think enough of the dusting business to continue with it. We have a very fine machine, and in excellent condition, which we will sell to the man who likes to use the dust."

From Henry M. Dunlap, Savoy, Illinois: "My experience with dust spray is very limited. I bought a dust machine and after operating it a half day was so disgusted with it I never used it again. The experience of others I considered sufficient."

From I. D. Snedeker, Plainview, Illinois: " * * * after several years' use of the dust in connection with sprays, and noting the results, * * I am not satisfied to abandon the liquid spray for the dust. The dust has the decided advantage in a quick application, requires less labor, less cost of investment in machinery, but the actual total cost of application is a trifle more than the liquid. * * * My observation leads me to conclude that dust has sufficient merit to continue in its experimentation. Just why some orchards we have dusted have shown wonderful returns and others a complete failure, I cannot say, but even when made on the same day, by the same crew, and under same apparent conditions, the results have been widely different. * * * However, it seems to me that dust is not to be preferred to liquid for the first sprays, but for second and following broods of codling moth, it shows too much promise to be condemned at this time, and it would be pleasing to us to see the work of experimenting with dust continued."

From W. S. Perrine, Centralia, Illinois: " * * * We had almost perfect results on peaches in controlling curculio, scab, and

[1]Mr. Simpson operated heavily in Illinois at the time when this work was done.

rot. However, we preferred to risk the liquid on our peaches this season, feeling that it was safer and less expensive.

"We did not have so good results on apples—it did not control blotch as well as liquid and on several occasions gave us quite severe injury both to fruit and foliage,—in two instances causing premature dropping of both leaves and fruit."

From G. F. Cadwell, Griggsville, Illinois: "In reply to yours of the 18th inst. will state that our experience with dust sprays has been very unsatisfactory and would not use them any more."

A letter from F. J. Sutton, representative of the Niagara Sprayer Company, dated at Kokomo, Indiana, December 26, 1920, says in part: "Mr. Albert McClay of Hillview has used dust for the codling moth applications for 4 years. This fall when I asked him the cause of the Illinois growers' failure to control scab with dust, he said he believed his own failure to control scab was due to the fact that, when he used dust four years ago for the complete summer schedule, he ran the dusting throughout the day and that, therefore, he had not given dust a fair chance. Now he operates his dusters from about 4 A. M. until 9 or 10 A. M. and, as he told me, he believes dust will control scab, when applied at that time of day."

Mr. A. L. McClay in a telegram dated at Hillview, Illinois, December 28, 1920, says: "In regard to my dust spraying results I have found dust of but very little value in the control of diseases and only about fifty per cent efficient in control of worms. Would not recommend using dust where it is possible to get water for the liquid spray."

From C. F. Heaton, New Burnside, Illinois: "We have no intention of using dust for codling moth or otherwise ever again."

From C. O. Clark, manager for F. P. Anderson, Anna, Illinois: "We have found dust spray a wonderful time saver and very effective for bloom spray if reasonably calm. Have never used for fruit spray."

That it is extremely dangerous to make a snap judgment on such a thing as the efficiency of dusting is shown by the following letter from F. D. Fromme, Plant Pathologist of the Virginia Agricultural Experiment Station: " * * * we have had results the past season which throw an entirely different light on the results which we reported in our bulletin 223. We used the same material this year in the same orchard and had no appreciable measure of blotch control at all. We have come to the conclusion that our striking results in the previous year were due in reality, not to blotch control by the dust, but to localization of infection. It is a strange thing that we should have located out plots in this manner. A new arrangement of the plots in 1920 revealed this to be true. The diagram which I am enclosing will illustrate the point. I believe now that the bordeaux dust which we used has little or no effect on blotch. It certainly has none on bitter rot."

Some Factors Influencing the Practical Control of Blister Canker in Apple Orchards

By H. W. ANDERSON, *University of Illinois, Champaign, Ill.*

IN an attempt to apply control measures for blister canker in Illinois orchards, certain factors of fundamental importance were revealed. These factors had to do with certain phases of the etiology of the organism causing the disease and with the condition of the host plant. The facts here presented are not entirely new since the splendid monographic work of Cooper in Nebraska, has emphasized them more or less, and other workers have given them some consideration.

The factors of importance in the etiology of the fungus are:

1. Source of infection. 2. Manner of infection. 3. Life of the fungus in the host.

The factors of importance in host consideration are:

1. Susceptibility of varieties of apples and wild hosts.
2. Conditions in the host which induce or encourage infection.

ETIOLOGY

1. The sources of infection are:

A. Ascospores. b. Conidia. c. Mycelium.

a. Ascospores are produced in the nail heads or stromata on cankers which, as a rule, have developed through one or more seasons. The ascospores are not produced on cankers appearing during the current year so far as Illinois conditions are concerned. They are discharged forcibly from the perithecia when the base of the stromata become soaked with water. This happens only after the bark has become thoroughly moistened. After being soaked, the discharge continues for some days even after the weather has cleared, so that the ascospores are not only washed about during rainy weather, but may be blown about as dust particles during subsequent, dry breezy days. The discharge may be seen with the naked eye under favorable conditions. The ascospores have a remarkably long period of vitality, extending over three years. Diseased limbs cut two years previously and used as props to support the over-loaded limbs, were found to contain viable spores. Undoubtedly, ascospores are the most important source of infection and may be regarded as the only source which should receive consideration from a practical control standpoint, aside from ordinary precautionary measures. The reason why they are so infectious are (1) their immunity from injury by ordinary weather conditions, (2) their long vitality, (3) their ability to infect readily when on the proper pabulum, (4) their

great abundance, and (5) the provisions for their wide dissemination.

b. The condidia are borne on the surface of the same stromata in which the ascospores are produced. They may appear during the first season or any subsequent season. They are produced in enormous numbers, but probably play little part in infection because of their very short vitality and the difficulty of maintaining contact with exposed surfaces sufficiently long to establish infection. They are quickly killed by drying. The main infection courts, as will be brought out later, are the large exposed wounds. Repeated attempts to bring about infection on these surfaces under natural conditions have always failed when the conidia have been used.

c. The mycelium is capable of infecting under favorable conditions. It may be carried in the wood between the teeth of a pruning saw, as has been proved a number of times by my experiments. Actual infection by this means has not been proved and attempts numbering about forty-five have, so far, failed, but it is probable that occasionally such infection does result.

Summarizing the above statements, the ascospores are the main source of infection, although both conidia and mycelia are to be regarded as capable of infection.

2. The manner of infection involves disseminating agents, infection courts, and physical conditions.

Practically nothing is known concerning disseminating agents. It is safe to say, however, that the usual agents, water, wind, insects, and animals, including man and his tools, are all involved. Spores are washed in great numbers from the surfaces of the cankers to points lower down. Wherever conditions are favorable, infection occurs. As was pointed out above, the ascospores are shot out into the air and the conidia consist of dusty masses so that both may be air-borne. Insects work diligently in the cankered areas and are especially active in the stromata. Just what these insects are, has never been determined, but frequently it is hard to find a single fruiting stroma on account of the fact that the interior has been destroyed by some insect. Just what part these insects play in dessemination is a matter for future investigations.

One of the most important factors in the control of blister canker is the place of infection on the infection courts. In the first place, the fungus is a wound parasite and will not enter sound bark. Secondly, it is primarily a wood disease and infects best in older wood. This means that large wounds and deep wounds are necessary for optimum infection. In my field experience and in artificial infection work, I found with Cooper that the great majority of infections take place in wood over three years old. The common points of infection in the orchard are large pruning wounds, stubs where limbs have broken off, deep frost cracks, and large dead areas produced by sun scald or other canker producing agents. Limbs which are partly killed, or in a weakened condition from shading, such as occurs on the lower parts of large, poorly

pruned trees, seem to be quite susceptible and may be infected through comparatively small wounds, such as those produced by small twigs breaking off.

The physical conditions influencing susceptibility are age of trees, vigor of growth and weather conditions. Of these, the vigor of growth plays a relatively unimportant part. My observations show that in a large orchard set on land ranging from very poor clay soil to rich, black loam, there was no more blister canker on the clay soil where the trees had made less than half the growth of those in the rich loam, than on the well nourished trees. This statement applies to Illinois conditions only. I am not prepared to state how important this factor is elsewhere.

Cooper claims that there is little difference between old and young trees so far as susceptibility to blister canker is concerned. But it is a well known fact that orchards under fifteen years of age show practically no canker. This may be due to the fact that trees under this age rarely have large wounds and the disease does not become established in these orchards. They also have less chance of infection due to the fact that they have much less heart wood in proportion to sap wood than the larger trees.

Weather conditions play an important part in infection. Unlike most fungous diseases, blister canker is a dry weather fungus. It has been observed by both orchardists and investigators that in regions where dry summers prevail, the trees are more severely attacked by blister canker; and, that following dry summers, the disease is much worse than during a season following a summer of abundant rain. Those regions having abundant summer rainfall are rarely seriously troubled by this disease.

3. Life of the fungus in the host. The mycelium of the blister canker fungus is not confined to the immediate neighborhood of the canker, but may be found several feet below or above the lesion. In fact, in badly cankered trees it may be present in limbs showing no evident external canker. It is easy to culture the fungus from diseased tissue and thus trace the course of the disease throughout the tree. The discolored heart wood which is so commonly evident is not always an index of the content of the infected area. There are present, however, small dark brown streaks in the wood near its outer edge which, according to Glover of New York, are the direct result of the invasion of wood elements and which consequently indicate the extent of wood invasion. These streaks gradually fade as they retreat from the cankered area. In cross section, these streaks are evident as large brown dots on the cankered side of the limb.

The fungus advances rapidly through the dry wood and for this reason the older the tree or the limb attacked, the more rapidly the spread of the disease. Thus, old trees are more generally found badly diseased than younger trees.

Host Considerations

1. Only certain varieties are subject to blister canker to a serious extent. I am confident that were Ben Davis elminated

from all orchards in Illinois, little trouble would be experienced from this disease. This does not mean that other varieties are not susceptible, but they are so rarely seriously diseased unless in the same orchard, or in the neighborhood of Ben Davis, that one is justified in making the above statement. Chenango, Gano and Willow Twig are other quite susceptible varieties. In addition, the disease has been observed on almost all varieties grown in Illinois. In other states, Grimes has been reported as quite susceptible.

A neglected factor in the consideration of this disease is the presence of wild hosts in or near the orchard. The most common wild host is the mountain ash. There are few of these trees which are not diseased and, according to Gloyer, the ascospores from this host are much more virulent than those produced on the apple. In New York where Gloyer is working, he has found the ascospore stage rare on the apple and thinks that the majority of infection came from Sorbus. In Illinois, this does not hold, but undoubtedly this wild host does play an important part in the life cycle of the parasite.

2. Conditions in the host which induce or encourage infection have been discussed in some detail in preceding sections and need not be repeated here.

A Plan for Practical Control of Blister Canker

Based on the facts given above, what methods should be used to control this disease?

If the orchard is as yet unplanted, the solution of the problem lies in avoiding susceptible varieties, especially Ben Davis and Gano.

If the orchard is young, the secret of control is an early recognition of cankers by careful annual surveys of the orchard, paying especial attention to any susceptible varieties. My advice would be to dig up and burn any trees in a young orchard showing this disease.

If the orchard is over fifteen years old and blister canker has become established, the procedure will depend upon the per cent of infection. If the number of infected trees does not run over ten to fifteen out of one hundred, it is well worth while to attempt to hold the disease in check by applying thorough control measures. If the percentage of diseased trees is over fifteen, it is hardly worth while to make a fight against the spread of the disease and control measures should consist in a few precautionary efforts to keep the remaining trees healthy as long as possible.

The main problem that confronts the station horticulturist and pathologist, is the condition so commonly met with in our middle west orchards. The orchardist at first sees some limbs dying. He cuts these off the first year or so, but when the number increases and some of the trees die, he becomes alarmed and sends a specimen to the experiment station. The horticulturist finds blister canker present and if he takes the troubile to survey the orchard,

finds it well established. It is rare, indeed, that the orchardist recognizes this disease when it first appears in his orchard.

Based on the facts outlined above, the following procedure is advised for an orchard of this type.

1. A thorough survey to find every diseased tree. Every tree in the orchard should be carefully examined during the winter months when the branches are bare and the cankers may be seen. One may either make the survey and mark the trees without doing any cutting out work or carry the tools along and do the surgical work as he goes. Under any condition the diseased trees should be marked by painting a broad red band about each trunk. *These trees should always be avoided during the regular pruning operations.*

2. All dead limbs and those where the canker has extended three-fourths the way around the limb, should be sawed off. In cutting off the limbs, the cut should be made below the last trace of the brown streaks described earlier. This is usually at least fifteen inches below the base of the canker. If possible, cut back to a large limb. These limbs should be collected and burned.

3. All cankers left from the above operations should first be treated by being sponged with a saturated solution of copper sulphate. This should be applied in such a manner as to thoroughly soak the "nail heads" and surrounding bark.

4. The dead bark from the canker and a strip of live bark one-fourth to one-half an inch wide around the edge of the canker should be removed. No special precautions to sterilize tools need be taken.

5. All wounds including those made by cutting off limbs should be painted. Painting is not so much a protection against reinfection as a protection against wooly aphis.

This work is most conveniently done in the winter time when the orchardist is doing his regular pruning work; but should be a separate operation. The object of the treatment is to get rid of all fruit bodies of the fungus. Soaking the bark before it is cut out kills the ascospores and renders them harmless when the stromata fall to the ground during the cutting out operation.

So far the treatment does not differ markedly from that given other cankers. At this point it must be remembered that the treatment here given does not get rid of the disease. Within a year, an examination of the bark at the edge of the cleaned out canker will reveal the reappearance of the disease in many cases. In some years and under certain little understood conditions, the fungus does not reappear on the surface, for a number of years at least, and the wounds completely heal. A good callous is often formed one year with no indication of the disease and the next season it may reappear. Cutting away all the diseased bark holds the fungus in check so far as reformation of fruit bodies is concerned. but usually these bodies appear again within one or two years. Thus, it is necessary to go over the orchard every year and cut out the new diseased area, look for new cankers on the infected trees, and examine the remainder of the trees for further evidence of

disease. As a rule, a few more trees will be found the first season by a resurvey, but if proper care has been taken of the orchard, very few new trees will be found diseased. It is also true that a number of trees may be diseased without having shown canker during the first survey. These may be expected to develop cankers within a few years.

The success of control depends upon the thoroughness with which the work is done originally. Constant following up, year after year, and above all the thorough training of one or two workmen who will superintend not only the cutting out of the cankers, but all pruning operations.

If the ascospores are destroyed and none allowed to develop subsequently, one may be certain that few, if any, new infections, will take place in the average orchard.

A survey should be made in the neighborhood of the orchard for mountain ash. If this tree is found, it should be destroyed since it is of little economic value and serves as a source of infection for neighboring orchards.

Some Important Factors in Snap Bean Production

By C. W. RAPP, *Arkansas Agricultural Experiment Station, Fayetteville, Ark.*

IT was not so long ago that the snap bean was, in the South, purely a home garden vegetable. With the introduction of improved methods of transportation, however, the snap bean became of importance as a trucking crop. Florida, Alabama, Mississippi, Texas, and Louisiana have for some time been producers and shippers of snap beans to northern markets. Within recent years, Arkansas and Oklahoma have begun the development of this industry.

The snap bean holds rather a unique position among the southern trucking crops. Unlike lettuce, tomatoes, cucumbers, radishes, and some other vegetables, the snap bean does not compete with the greenhouse or forced product upon northern markets. Although sometimes grown under glass, the snap bean is not one of the more important forcing crops. The trucker need fear no serious competition from this source.

The southern trucker deals in large acreages. He depends for his profits upon producing his crop at a time when the product of his locality or section has the ascendency at the principal markets. The snap bean is admirably adapted to his use. It grows rapidly and produces a marketable crop within a short time after planting. It can be planted and matured during that part of the season best adapted to its growth.

The majority of the southern snap beans grown for northern

markets are matured during the winter and early spring. The crop coming at a time when vegetables are scarce and, therefore, in great demand, is usually popular, and is often very profitable to the grower.

Snap beans are grown to a certain extent over the entire southern trucking area. The product from Florida opens the market early in December. Production from these districts, by a succession of plantings, is continued until April. This production is augmented at more or less regular intervals by the crops from various trucking sections from the Gulf northward.

It frequently happens that the crop from one trucking region enters the market just as the production of another section is about exhausted. This is the ideal condition. Some trucking districts on the outskirts of the southern area have discovered that very early planting brings their crop into direct competition with the crop of more southern sections. They have, in some cases, found that their seasonal returns from a somewhat later crop average higher than from very early planting, because of the elimination of southern competition. This also allows them more time to devote to other early crops and almost elminates the frost danger.

Certain of these sections are now growing a second or fall crop of snap beans. The warm falls have been found to favor high yields. A very good market for this late crop has been found in the Mid-West. As yet it appears that the full possibilities of this second or fall crop have not been fully realized by the grower It seems certain that a much greater market can be developed for the late crop.

In many of the southern trucking areas diseases have proven an important limiting factor. In most cases it has been found that the fall crop is much less seriously attacked than is any other. Edgerton of Louisiana has done extensive and valuable work in this line especially in the control of anthracnose. He has found that the fungus causing this disease is unable to withstand the continued high temperature of the summer months. Due to this fact seed grown during the fall is disease free and such seed when used for the main crop produces pods free of anthracnose.

Another disease of great importance in some snap bean sections is bacterial blight, caused by the bacterial parasite, *Bacterium phaseoli*. This disease is at times very destructive. It is not uncommon for pods found on the market to show from ten to ninety per cent infection. The loss in yield is also greatly reduced, sometimes from twenty-five to fifty per cent and even more, due to the destructive action of the organism upon the leaves and stem as well as upon the young pods.

The control is difficult. Sprays are of little if any avail and many methods of seed treatment have been tried with very little success. The author of this paper, while on the staff of the Horticultural Department of the Oklahoma Station, conducted extensive experiments in the hope of evolving some effective and practical control measure for the ordinary grower. It was discovered to be a very difficult problem. The disease, even though present, can fre-

quently not be detected on the seed except by bacteriological methods. This is of course entirely impracticable for any except experimental use.

Seed selection from apparently healthy plants bearing healthy pods did give disease free seed. This method is however very tedious and requires the use of a seed plot as well as careful observation during the growing season.

The most successful method evolved was in the use of stored or aged seed. It was found that infected seed, when held over a two year period under Oklahoma conditions and planted on disease-free soil, will yield disease-free plants. At the same time the vitality was yet sufficiently high to make this method practicable.

The germination tests conducted in determining the possibility of the use of aged seed in controlling bacterial blight furnishes some interesting results.

Laboratory tests conducted with sterilized Geneva testers indicated that seed held over a period of four years might be safely used. This same work when repeated under almost ideal field conditions gave far different results. It was found that seed held over a two-year period might be planted with safety, but that seed three years old and older was of doubtful value. Certain varieties however seem to retain their vitality longer than others and further experiments might show that these could be used after three, four, and even five year periods of storage.

In this connection it should be stated that all seed used in these tests was grown on the station grounds and had been stored under identical conditions.

The following table clearly shows the discrepancies between the two tests:

A COMPARISON OF TESTER AND FIELD GERMINATION IN BEAN SEED

Variety	Germination Percentage	
	Tester	Field
(One Year Old		
Round Yellow Six Weeks	100	92
German Black Wax	100	94
White Marrowfat	94	94
Longfellow	100	88
Average	98.5	92
Two Years Old		
Round Yellow Six Weeks	88	94
German Black Wax	100	92
White Marrowfat	86	86
Longfellow	96	92
Average	92.5	91
Three Years Old		
Rust Proof Golden Wax	100	78
Burpee White Wax	92	58
White Marrowfat	100	82
Longfellow	78	64
Average	92.5	70.5
Four Years Old		
Round Yellow Six Weeks	88	94
Extra Early Refugee	82	22
White Marrowfat	100	36
Hodson Long-pod	64	56
Average	83.5	58
Five Year Old		
Round Yellow Six Weeks	66	82
Universal Wax	0	4
White Marrowfat	20	2
Longfellow	54	0
Average	35	22

The use of aged seed in controlling bacterial blight has proven practical. The question now resolves itself into how long this seed may be held and retain sufficient vitality to make its use possible in commercial planting.

Hydrocyanic Acid Injury to Tomatoes*

By Geo. F Potter, *Agricultural College, Durham, N. H.*

HYDROCYANIC acid gas, generated by the action of dilute sulphuric acid upon potassium or sodium cyanide is the most effective insecticide for the control of white fly (*Aleyroides sp.*) and some other greenhouse pests. In its use, however, serious injury to the host may occur. The need of exact knowledge of the conditions which result in excessive burning has stimulated investigation by several botanists, entomologists and horticulturists.

Several obvious factors may cause inconsistent results in fumigation Leakage varies in different green houses. Loss from this source is increased by wind, and also by rain owing to the high solubility of the gas in water. Closely related to this is loss of effective gas by absorption in moist materials within the house. Penny (6)† has found that whereas 72 per cent of the theoretical yield of gas contained in a dose of potassium cyanide may be recovered in a closed box five minutes after the reaction, when a layer of most leaves is included only 54 per cent may be recovered at the end of the same period. With no leaves included, but with the box resting on moist soil, a still greater reduction of the effective gas occurs. For experimental purposes these errors must be eliminated, and in practice they should be reduced to a minimum by keeping the house dry before fumigation.

Equally interesting work has been done by McDonnell (3) who has shown that from 1 to 12 per cent of the total cyanogen of KCN or NaCN may be retained in the residue in the reaction chamber, depending upon the relative amounts of cyanide, acid and water used. In general the least gas is retained when equal parts of acid and water are used. Impurities in the cyanide in the form of chlorides and nitrates tend to form hydrochloric and nitric acids which react with the hydrocyanic acid destroying additional increments of it.

The experiments reported here were performed in a box of about 54 cubic feet capacity, parafined inside to prevent all leakage. Errors due to absorption or other causes were carefully guarded against.

The response of the plant to various concentrations of hydrogen cyanide are varied. Low concentrations may temporarily increase the growth of tomatoes, as has been shown by Clayton (2) and Moore and Willaman (5). Moore and Willaman have shown further that the activity of the respiratory enzymes is temporarily inhibited. Respiration as measured by carbon dioxide production in the dark is also temporarily reduced. Photosynthetic activity is rendered below normal sometimes for a period of three days and

*The data presented in this paper were obtained at the Wisconsin Experiment Station.

†Reference by number to literature cited.

probably on this account repeated fumigations may result in a decreased size of plant. Translocation of starch may be retarded due to failure to utilize sugar in the growing tips of the plant. Slightly stronger doses result in distortion of the growing tips, botanically termed epinasty.

Responses of this nature are not on the whole of great practical importance, but as the gas concentration increases, killing of the leaves, of the growing tips, or even of the entire plant results. The cause of this injury or the manner in which the cyanide causes death is not definitely known. With animals cyanide is believed to inhibit oxygen transfer necessary for respiration, and hence kills by suffocation. It has been objected that the action in plants must be different because, although cyanide may kill in a half hour, the plant can be kept without injury for many hours in an atmosphere devoid of oxygen. In this case, however, intramolecular respiration takes place. If the respiratory enzymes such as catalase are paralyzed by the gas, even this form of respiration may be inhibited and the death of the tissue may be actual suffocation.

Clayton (2) has shown with tomatoes and Stone (8) with cucumbers that plants grown in a relatively dry soil, and consequently making a slow growth, can withstand higher concentrations of the gas than plants grown in moist soil. Stone showed further that cucumbers grown in partial shade were especially susceptible to injury. Clayton found a higher content of reducing sugar in the resistant than in the susceptible plants, and plants infiltrated with glucose were found to suffer less in fumigation than plants similar in other respects.

Fumigations during the daytime have uniformly been found to be more injurious than fumigations at night. This difference has been ascribed to the fact that the stomata are closed at night. Moore (4) takes exception to the theory that the gas enters through the stomata, and explains the difference in resistance of different species of plants on the basis of differences in the thickness and suberization of the cuticle. He performed experiments which showed that under high concentrations the gas may pass through the cuticle, and that relatively more gas enters when the cuticle is thin. Tradescantia is one of the plants classified by Moore as susceptible because of thin cuticle, as is also the tomato. Clayton (2) showed that at least in daylight fumigation, the leaves of Tradescantia are more completely protected against injury by coating the lower or stomatal surface with wax, than by coating the upper surface. One of these experiments, which were not extensive, also indicates that a slight protection may result from waxing the upper surface.

Probably the most important factor in determining the rate of absorption of a gas is its solubility in the film or membrane into which or through which it is passing. To produce injury, hydrogen cyanide must be absorbed whether it enters through the cuticle, or whether it passes through the stomata. It is listed in Olsen's chemical annual as infinitely soluble in water, hence it would be ab-

sorbed with extreme rapidity by the saturated walls of the mesophyll cells. The diffusive capacity of the stomata has been shown by Brown and Escombe (7) to be very great and this fact taken together with the greater solubility of the gas in a water saturated than in a dry suberized membrane, make it appear improbable than any large proportion of the gas would pass through the cuticle. It would seem quite likely, therefore, that the limiting factor governing its entrance into the plant would be the rate at which it diffuses through the stomatal aperatures, especially since most fumigations are carried on at night when the stomatal apertures are relatively small.

The following experiment shows, however, that injury to the tomato does not bear a simple relation to the rate at which the gas is able to pass through the stomata, or is absorbed by the cells. The maximum concentration of the gas which can be used without injury at each of six different lengths of exposure was determined experimentally. Plants grown under uniform conditions in sets of four in a small pan were used, and the environmental conditions were maintained the same in all trials. The results are shown in Table 1.

TABLE I

Maximum Safe Dose for Different Lengths of Exposure. Temperature 70°F. Relative Humidity 70% Plants Turgid. Time in Hours.

Ounce KCN per 1,000 cubic feet	¼	2	4	6	8	10
Experimental determination	2.2	0.8	0.5	0.35	0.35	0.30
Computed *	2.0	0.7	0.5	0.40	0.35	0.32

*Note—For method of computation see text.

If in all cases the same quantity of gas must enter the plant to produce injury, and this appears to be the only logical assumption, the lethal concentration of gas for a two hour exposure should be just double that for a four hour exposure, because the rate both of diffusion through the aperatures of the stomata and absorption by the membranes should be proportioned to the concentration of the gas. As experimentally determined, the lethal dose is not directly related to the time of exposure, but is almost exactly inversely proportional to the square root of the time. Calculations on this basis are shown in Table I using the formula $D = \frac{1}{T}$ where D is the dose in ounces per 1,000 cubic feet and T is the time in hours. The agreement between calculated and observed concentrations is very close.

It is evident that in the longer exposures it becomes increasingly difficult for the gas to enter. Moore and Willaman (5) observed a contraction of the stomata when tomatoes were exposed to the gas. This tendency may at least partially explain the

greater concentrations of gas endured without injury at long exposures. Armstrong (1) has observed a decrease in permeability to sugar in leaves immersed in a weak solution of cyanide, and this has been confirmed by Moore and Willaman (5). Decreased permeability might slow down the absorption process in long exposures. Philip states that when the absorption of a gas is not proportional to the concentration, a chemical reaction is taking place between the gas and the liquid in which it is being absorbed.. Usually, however, such a reaction increases the amount of gas taken up at low concentrations, the reverse of what is absorbed here. Possibly in long exposures the plant is able to decompose, or otherwise throw off, a portion of the gas so that more gas has to enter to produce injury. Certainly the injury to the plant is not simply regulated by the quantity of gas which may enter by purely physical means.

Relative humidity was tested by the writer as a factor which might influence the amount of injury to the plant. Only two series of plants were used. The data are given in Table 2.

TABLE II

Influence of Relative Humidity on Maximum Safe Dose. Exposure 10 hours. Plants wilted.

Average Temperature	Average Relative Humidity	Maximum Safe Dose, Ounces KCN per 1,000 cubic feet
74	86.5	0.4
70	77.0	0.5
72	70.0	0.5

Results varied more in this series than in the other determinations, but apparently under high humidity the dose must be reduced somewhat. Moore (4) has published similar results, although his data also are not extensive.

It has been suggested that high humidity causes an opening of the stomates. This could not have occurred in the experiments above, because the plants were all wilted. The theory that the stomata respond to changes in humidity in order to control transpiration has also been questioned, hence this explanation is hardly tenable. Moore has shown definitely that plants fumigated under the same conditions are benefited by a low humidity after removal from the gas. This is probably due to elimination of gas in the intercellular spaces.

High humidity reduces transpiration. A second lot of plants grown under the same conditions were fumigated with different moisture contents in the soil. A series of five pans were used for each fumigation in which the water content ranged from dry enough to cause wilting in the first pan to practically saturated in

the fifth. Moore has shown by tests in which the surface of the soil was parafined that injury from absorption of the gas in the soil is not a factor. This series should therefore indicate the importance of transpiration rate. The data are given in Table 3.

TABLE III

Influence of Soil Moisture Content on Maximum Safe Dose. Exposure 10 hours. Temperature 70°F. Relative Humidity 70%

Series No.	Per cent water in Soil	Maximum Safe Dose, Ounce KCN per 1,000 cubic feet	Condition of Plant
1	6 9	0.50	Wilted
2	8 10	0.45 to 0.50	Usually slightly Wilted
3	12 14.2	0.35	Turgid
4	18–20	0.35	Turgid
5	25–30	0.35	Turgid

Marked immunity to strong fumigation follows wilting, probably due to the practically complete closure of the stomata which usually follows wilting. It is difficult to conceive of wilting causing so striking a change in the permeability of the cuticle. Transpiration rate in itself is not important as is indicated by the last three series. This leaves the injurious effect of high humidity without explanation.

Temperature is another variable factor in greenhouses which deserves and has received some attention. Tower and Fernald (9) thought temperature and moisture of little importance. Moore (4) decided that a high temperature gave least injury. Clayton (2) found greater injury at high temperatures. The writer's data are given in Table 4.

TABLE IV

Influence of Temperature on Maximum Safe Dose. Exposure 10 hours. Plants Wilted.

Temperature in Degrees F.	Average Relative Humidity	Maximum Safe Dose Ounces KCN per 1,000 Cubic Feet
70	77	0.50
85	60	0.25

Plants were completely killed when fumigated at 86° F with the same dose which was repeatedly used at 70° without any injury. It may be noticed that the plants fumigated at high temperature had the advantage of low humidity. This would be likely to be the case whenever the temperature of the greenhouse is raised.

It is interesting to note in this connection that absorption of a

gas by a liquid or a membrane is decreased by a rise of temperature. Entrance of the gas through the cuticle would tend to be reduced by higher temperature. Entrance of the gas through the stomata would tend to be increased, although not enough to account for the large difference in lethal dose shown here. Chemical reaction is hastened and it seems most plausible to believe that the chief reason for increased injury at high temperature is that the action of the gas within the tissues is accelerated.

It has been only too evident that the problems of fumigation have not yet been wholly solved. It is believed that the data presented here on the whole favor the theory that the gas enters through the stomata.

The findings which have already been made point the way to greenhouse practice which will materially reduce injury to plants. The following rules are suggested:

1. The same formula for generating the gas should always be used, and the fumigations should all be done under similar weather conditions.
2. The floors, walks, and soil of the houses should be as dry as possible.
3. The dose should be decreased under high temperature.
4. It is objectionable to cool down a house before fumigating because this raises the humidity.
5. Plants may be expected to be very susceptible to injury after periods of dark weather or after growing vigorously in moist soil.

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The Effect of "Nipping" Muskmelon Vines

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THE recommendation that muskmelon vines be "nipped," "pinched," or "stopped" by the removal of the growing tip is quite common in vegetable gardening literature. Among modern American authors who make definite statements regarding the desirability of thus treating muskmelon vines, the following may be mentioned: Peter Henderson, P. T. Quinn, S. B. Green, T. Greiner, W. Atlee Burpee, Allen French, Chas. A. Selden, Adolph Kruhm. The recommendation is without question based upon the fact that the fruit of the muskmelon is borne principally upon the laterals or side branches rather than upon the main or central shoot of the vine. In fact several authors state definitely that the object of the nipping is to force out the laterals on which the fruit is borne. Claims are made that this treatment induces earlier fruiting, increases the yield, and even improves the quality of the product.

The stage in the development of the plant at which it is recommended the nipping be done varies from soon after the second rough leaf is formed to "when the vines have grown several feet in length." Definite recommendations between these two extremes are "when the plants begin to run," "when the vines are about twelve inches in length," and "when about eighteen inches long." Recommendations favoring extremely early nipping have reference to the culture of the melon in frames, where only one plant is grown in each hill. This early nipping causes the formation of two laterals (one from the axil of each of the first two rough leaves) which are trained in opposite directions to more fully occupy the frame. These laterals are later nipped to promote the formation of sub-laterals on which, in this case, the fruit is borne.

The most specific and detailed instructions regarding nipping are given in some of the older American works on gardening which

are plainly based upon European practice, and in modern European writings. These directions all have reference primarily to the growing of melons under glass in restricted areas, and it is probable that the recommendations made by Henderson and later American writers have been carried over from the earlier amateur practice and writings, with such modifications as would seem to render them more applicable to outdoor culture of the melon.

In order to secure data in reference to the effect of nipping melon vines grown under field conditions in Illinois, tests were made for five years in Union county and for three years in Marion county, making a total of eight separate tests. In each case, plats of melons were planted, consisting of sixty-four hills each. In one plat the tips of the vines were nipped off when the plants had reached a length of about one foot; in another plat the vines were allowed to grow without nipping. The two plats were treated exactly alike as to fertilizing, tillage, spraying and other care.

The melons were picked as they ripened, and a careful record was kept of each day's picking. These melons were shipped to market along with those from other experiments being conducted at the same time. A record was kept of the selling price of melons each day during the shipping season. In making up the yield records from the daily picking records, a division was made between early and late melons. Those which ripened early in the season, before shipments from the region became heavy, and while prices were normally high, were designated as early melons, and the balance of the crop as late melons. This may appear to be an arbitrary method of separating early from late melons, but it is the most significant method from a commercial standpoint.

Using this basis of designating early melons, there was a greater yield of early melons from the nipped vines in five tests out of the eight, and a smaller yield in three tests. If, however, the yields from the eight tests are averaged, it appears that the nipped vines yielded slightly less than the vines that were not nipped, the yields being .99 pounds per hill from the nipped vines and 1.02 pounds per hill from the vines that were not nipped.

In reference to total yields (including both early and late melons) there was a greater difference in favor of the vines that were not nipped. In six tests out of the eight, the vines that were not nipped outyielded those which were nipped. The average yield from the nipped vines was 3.14 pounds per hill, while that from the unnipped vines was 3.49 pounds per hill, or a difference of .35 pounds per hill in favor of not nipping.

The results of this experiment in Illinois, involving eight tests, are in harmony with the results of a test at the New Hampshire Station, reported in Bulletin 70 of that station. In the New Hampshire experiment, the vines in one row were nipped when they were three feet long "and then the laterals were again nipped or pinched in, not allowing over one or two fruits to set on each." In another row "the main vine was pinched, but no laterals." In three rows the vines "were allowed to take their natural growth." Ten hills had been planted in each row. The average yield of melons from

the vines that were not nipped was 16 pounds per hill, while the average yield from the nipped vines, including both lots, was 15.7 pounds, or an average loss of three tenths of a pound per hill apparently due to the nipping. The vines of which the laterals as well as the main vine were nipped, yielded slightly better than those of which only the main vine was nipped, but more labor was required to do the nipping. The conclusion was reached that there is "little if any gain from pinching or heading-in the muskmelon when grown out of doors."

It would appear that the value of nipping muskmelon vines, especially as applied to American field conditions, has been over estimated. Theoretically, the removal of the terminal growing point of the vine should induce the early and abundant formation of laterals; and since the laterals bear the fruit, it might seem that both earliness and productiveness should thus be promoted. However, the formation of laterals is dependent fully as much upon the general vigor of the vines as upon stoppage of the growing point. A melon vine will usually throw out fruiting laterals as early as it has attained sufficient growth to properly support any fruits that may set. A strong vine does not require nipping to make it form laterals; a weak vine needs other treatment than nipping to make it fruitful. Earliness and productiveness in muskmelons may better be promoted by liberal fertilizing and careful tillage to promote vigorous vine growth, than by nipping the vines to force the formation of laterals.

Preliminary Report on Onion Dormancy Studies*

By H. A. JONES, *University of Maryland, College Park, Md.*

DORMANCY has been a much studied phenomenon during the last few years. The recent investigations on the causes of dormancy by Crocker, Appleman, and others, have placed dormancy problems within the realms of research and investigation. Ability to control dormancy is of immense practical importance in the case of many seeds, bulbs, and tubers. It is both practicable and profitable in certain cases to abbreviate the dormant period and it would be desirable and profitable in other cases to prolong the dormant period of handling in such a way as to retard or delay the processes that in time make growth possible.

Observations in several of the middlewestern and northeastern states in onion fields and onion storage houses caused the author to believe that the onion bulb was dormant for some time after harvest and that this dormant period varied under different condi-

*The greater portion of the data presented in this paper was obtained by the writer while a member of the staff of the West Virginia Agricultural Experiment Station. Permission to use these data was courteously given by the authorities of the above Station.

tions of handling. An onion dormancy project was therefore studied in the spring of 1919 at the West Virginia Agricultural Experiment Station with the purpose of investigating the truth or falsity of this assumption.

The problems that it was hoped this work might solve in the course of time were as follows:

1. Does the onion bulb have a true dormant period.
2. If the onion bulb does have a true dormant period, what are the factors that cause this dormancy.
3. Is it possible to develop methods of pulling, curing, and storage that will lead toward the intensification and retention of those factors that cause dormancy in the onion.
4. What is the variation in the dormant period of different commercial varieties handled in a similar manner.
5. Are the variations in the dormant period of individual specimens of the same variety great enough to make possible strain selections having periods of dormancy more prolonged than the average for that variety.

The ultimate aim of the work is to select out strains, if possible, and develop methods of handling by use of which the great loss of onions each year in curing and storage due to secondary growth may be decreased. It is not the purpose of this paper at this stage of the investigation to advocate or recommend practices that should be followed in the handling of commercial crops of onions. The mission of this paper is to tell in a general way what studies have been started and the trend of this work since its inception in 1919. Due to the writer accepting a position in another state this last summer very little work was done in 1920.

Onion seed of Yellow Globe Danvers (obtained from Landreth Seed Company) was planted in the spring of 1919. A portion of this crop was pulled on July 29 just after the tops fell naturally. At the time of this pulling, the tops and roots were still green. A portion of the bulbs was cured on the ground in windrows and the remainder was cured in slatted crates in the field. In this paper there will be considered only those onions pulled just after the tops fell on July 29 and cured in windrows. Onions were left lying on the ground in windrows until September 27, a total of 60 days. These onions were not stirred but were left lying as thrown in the windrows. During this time 10.77 inches of rain fell upon these onions and according to field records 32 days of this period were partially or entirely cloudy. In addition the onions were lying on heavy clay soil which was moist most of the time. In spite of these unfavorable conditions for field curing no roots were evident until the latter part of September. Roots appeared at that time on a large number of the bulbs lying with the basal end in contact with the soil.

In order to check up on onions cured in windrows, relative to time for growth to start, a similar pulling was placed under more favorable growth conditions. These onions were planted at various times in the greenhouse in rich garden loam. These bulbs were examined at times indicated in Table I.

TABLE I

Table Showing the Time Required For Growth to Take Place in in the Greenhouse. In No Case Were Bulbs Planted That Showed Growth of Roots or Tops.

Lot No.	Days in Windrows and Storage	Date of Plotting	Growth August 16	Growth September 9	Growth September 24	Growth October 8	Growth November 8	Growth December 13
1	Windrow 2 days	July 31, 1919	No Growth	95 per cent no growth. 5 per cent short roots.	45 per cent no growth. 45 per cent short roots. 10 per cent short roots and with tops appearing.	65 per cent roots only. 35 per cent roots and tops.		
2	Windrows 42 days	Sept. 9, 1919			58 per cent root growth. 42 per cent no growth. No top growth.	12 per cent no growth.		
3	Windrows 60 days Temporary storage, 27 days.	Oct. 24, 1919					All rooted 80 per cent had 1 to 10 inch tops.	100 per cent tops and roots. Tops average height 2 ft. 5 inches.
4	Windrows 60 days Temporary storage, 48 days; permanent storage (32° F) 20 days.	Dec. 5, 1919						All rooted All had ½ to 2-inch tops.

From this table it will be seen that the bulbs planted in pots showed root development at about the same time as those lying in the windrows in the field. Onions planted in the greenhouse July 31 and September 9 showed approximately the same percentage of dormant onions on September 24. The bulbs planted July 31 and September 9, showed 45 to 42 per cent dormancy on September 24, having been potted 55 days and 15 days respectively. After 69 days all those pulled on July 31 had roots developed, but only 35 per cent showed top growth. All of the bulbs planted October 24 had roots and 80 per cent had tops 1 to 10 inches long after 15 days. All of the bulbs planted December 5, had roots and one-half to two inch tops after eight days. As the season advanced less and less time was required for growth under favorable conditions.

Another lot of bulbs was wounded in several ways to determine the influence of this wounding upon the dormant periods. Table II shows in a striking way the rapid growth responses following certain types of wounding.

TABLE II

Data Show Influence of Wounding on Root and Top Growth. Lot A is the Same as Lot 2, Table I, Used There for Comparison.

Lot	Condition of Onion Bulb	Number of Days in Windrows	Date of Wounding and Plotting	Growth on September 24
A	Entire	42	Sept. 9, 1919	58 per cent have roots appearing; 42 per cent show no indication of top or root growth.
B	Bisected transversely	42	Sept. 9, 1919	100 per cent growth of both tops and roots; root growth heavy. Tops averaged 10 inches in height.
C	Longitudinal cutting through root end	42	Sept. 9, 1919	No top growth 100 per cent root growth by far heaviest root growth of any.

Another lot was handled somewhat similar to those in Table II. Unwounded bulbs were planted July 31. When examined August 16, no growth of roots or tops was found. The major portion of these were wounded in various ways on the latter date and then repotted. In this case also transverse bisecting of the bulb stimulated both root and top development. Wounding basal end of bulb by cutting into stem and root region did not stimulate top development, but did stimulate root development very markedly. Root and top growth were initiated only when a transverse section removed the central scales or leaf bases from the upper part of the

bulb. Root growth but not top growth was initiated by cutting into the root and stem region.

There is a great variation in the dormant period of individual bulbs within the Yellow Globe Danvers variety. While most of the bulbs started growth under good growing conditions in 55 to 70 days, a few preceded the general average time, while a few remained dormant for 85 to 90 days.

Some observations have been made in the field on the relative dormant periods of different varieties. It can be said that some varieties have a dormant period considerably shorter than that of the Yellow Globe Danvers when handled similarly and these are notably those varieties that are notoriously poor storage onions.

Discussion

Up to the present time very little work has been done on bulb dormancy and the factors causing bulb dormancy, far more work has been done on seeds, buds, and tubers. One of the important questions to be answered before great progress can be made in prolonging the dormant period is what factors and conditions cause dormancy. No definite conclusion can be drawn with the meagre amount of experimental data at hand. Some suggestions are offered, however, due to the behavior of dormant bulbs following certain types of wounding. It is not known whether the same conditions that initiate top development also initiate root development. Root growth, in the case of transverse wounding may be merely correlated with top development. It is possible that there is some substance in the bulb which is liberated on removal of upper portion of scales and which is toxic to growth. Or there may be a deficiency of oxygen in the tissue for growth as found by Appleman[1] for the potato.

It would be natural to suppose that transverse wounding would allow more easy access of oxygen especially to the top growth region.

Cutting into the root and stem region at the base of the dormant bulb caused roots to develop within a few days, but top growth was not correlated with this root development. Cutting away a longitudinal portion of several of the outside scales did not induce root or sprout growth.

The leaf bases may act as semipermeable membranes, at first entirely or partially impermeable to oxygen or other gases, but becoming progressively more pearmeable and in time allowing growth to take place.

It is doubtful if the moisture content of the onion bulb has a great deal to do with the dormant period. Water in sufficient amount may hasten growth after the period of dormancy, or lack of water may be a factor retarding the growth period of the same as low temperature retards the development of buds in late winter although the dormant period is entirely over.

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[1]Appleman, C. O. Study of Rest Period in Potato Tubers. Md. Agr. Exp. Sta. Bul. 183, 1914.

The development of a strain of onions with a dormant period longer than the average for that variety is possible if this character in all its intensity is transmitted to the progeny. There is plenty of opportunity for selection due to the wide variations iin the dormant period within the variety.

Irrigation as a Factor in Seed Potato Production

By H. O. WERNER, *University of Nebraska, Lincoln, Neb.*

DURING the last few years a considerable number of tuber line studies with potatoes have been made and results published. They have caused considerable doubt concerning the reliability of the hill selection method as formerly quite generally recommended in bulletins and books. Our experience in western Nebraska during the last few years has caused us to arrive at conclusions somewhat different from those of some other investigators. Some workers seem to have entirely discarded the hill, or tuber unit selection system.

The special soil and climatic conditions most favorable for the perfect development of the potato plant, should always be kept in mind. Conditions that affect the plant unfavorably from a physiological standpoint will probably affect the tubers produced by the plant the same way, as the tubers are a very real part of the plant. Even though the yield of tubers produced by a plant may be very good, some condition under which the plant was grown may have been sufficiently unfavorable to cause the tubers produced when used as seed, to give very unsatisfactory results. A few of these factors that do have a very marked influence on the potato plant are atmospheric temperature, soil temperature, soil moisture, soil texture or structure, and of course diseases of known or unknown origin. Some one, or several, of these factors, have entered into the work of the various investigators. They all need to be considered in arriving at true conclusions.

At Nebraska, Emerson demonstrated that northern potaoes grown in eastern Nebraska deteriorated at the rate of 25 per cent the first year when used for seed. This was caused by high mean soil temperature and a long growing season. When the soil temperature was reduced from 10 to 12 degrees by means of a deep straw mulch, good seed potatoes could be produced in eastern Nebraska. In the work reported by Stewart from New York and Whipple from Montana, the various physiological diseases contributed as very serious factors. In Minnesota, Wellington found that very local conditions, possibly soil texture, was a serious factor in affecting seed quality of tubers produced.

Extensive investigations carried on in western Nebraska indicate that irrigation is a very serious factor in the effect it has upon

tubers to be used for seed purposes. This has an important bearing from a commercial standpoint, and an equally important one from a scientific standpoint.

The climatic conditions in western Nebraska are favorable to potato production. The altitude is from 3,500 to 5,400 feet. The annual rainfall averages from 15 to 18 inches. Summer days are

TABLE I

Triumph Potatoes at Minatare, 1917, Distribution of Population. Total Yield Basis—Mean of 450 Units—9.575 Pounds Per Unit—420 Bushels Per Acre.

Weight Per Unit, Pounds	Per Acre Rate, Bushels	Number of Units	Per Cent Group is of Population by Numbers	Per Cent of Total Weight by Group
.0	0.00	2	0.44	.00
.5	21.88	6	1.33	.07
1.0	43.75	6	1.33	.14
1.5	65.63	11	2.45	.38
2.0	87.50	17	3.78	.79
2.5	109.40	11	2.45	.63
3.0	131.25	22	4.89	1.53
3.5	153.13	33	7.33	2.69
4.0	175.00	15	3.33	1.39
4.5	196.88	15	3.33	1.57
5.0	218.75	14	3.1	1.62
5.5	240.63	11	2.45	1.41
6.0	262.50	6	1.33	.83
6.5	284.30	4	.88	.60
7.0	306.50	8	1.78	1.30
7.5	338.40	3	.67	.52
8.0	350.00	4	.88	.75
8.5	371.90	1	.22	.20
9.0	393.75	4	.88	.83
9.5	415.60	7	1.56	1.54
10.0	437.50	4	.88	.93
10.5	459.30	10	2.22	2.44
11.0	481.30	17	3.78	4.34
11.5	503.20	6	1.33	1.61
12.0	525.00	18	4.00	5.02
12.5	546.90	20	4.44	5.80
13.0	568.80	22	4.89	6.63
13.5	490.70	24	5.33	7.52
14.0	613.00	20	4.44	6.50
14.5	634.80	23	5.10	7.74
15.0	656.25	23	5.10	8.00
15.5	678.20	15	3.33	5.40
16.0	700.00	12	2.70	4.45
16.5	721.80	12	2.70	4.60
17.0	743.75	5	1.11	1.97
17.5	765.60	6	1.33	2.44
18.0	787.50	4	.88	1.67
18.5	809.30	2	.44	.86
19.0	831.25	1	.22	.44
19.5	853.00	2	.44	.96
20.0	.00	0	.00	.00
20.5	.00	0	.00	.00
21.0	918.80	4	.88	1.95

warm and clear and nights are invariably cool. The prevailing soil type is a well-drained fine sandy loam.

The data presented with this paper are only a small part of the total available. A more complete report will be issued later.

At Minatare, Nebraska, in 1917, 1,000 Triumph potatoes as nearly uniform in size and type as could be secured from the bin, were planted by the standard tuber unit method in part of the field of a very careful grower. The potatoes had been grown on this same farm in 1916. The history of the seed prior to 1916 is uncertain. The potatoes were generously irrigated during the season.

Considerable variation in vigor between units was manifested during the growing season. At digging time the yield of each 4-hill unit was recorded. (Records were taken of the first 450 units.)

According to Table 1 the mean yield per unit was 9.575 pounds, or at the rate of 10,500 plants per acre, are the mean yield of 420.4 bushels per acre. The distribution of the units according to yield is unusual. They do not group themselves so as to form a normal curve. A study of Table 1 indicates that there are really two modes, one at 3.5 pounds per unit with 33 units, the other at about 13.5 pounds with 24 units. Exactly half way between, at 8.5 pounds per unit, is the low part of the curve, with only one unit represented. Thus there were two distinct groups of plants within this group, a high and a low yielding group with very few intermediates. Each group had its own mean and each group formed a normal curve by itself. These groups are the result of heritable differences as the units of each group were geographically scattered over the entire field. There were 200 units below the mean of 9.575 pounds per unit. These represented 44.4 per cent of the total population, but only 18.8 per cent of the total production, whereas, 250 units above the mean represented 55.6 per cent of the population and 81.2 per cent of the total production. The mean per acre difference in yield between these two groups was 412.72 bushels with the lower group producing at the rate of 199.07 bushels and the upper group at 611.85 bushels per acre.

Dry land grown potatoes have never acted for us in this style. Their population when plotted always produces a normal curve.

In 1918, seven dry land units (tuber unit in 1917) were brought down from Alliance (40 miles northeast) and planted in comparison with 14 of the original Minatare Triumph units. From 50 to 100 hills, or more, of each unit were planted. The dry land units were all uniformly vigorous and high yielding except one which had been selected as a low unit. The irrigated units varied greatly within the units with regard to vigor. It will be observed from Table 2 that the dry land seeds yielded more than the irrigated stock. The lowest dry land unit yielded more than the best irrigated unit.

In 1919 and 1920, fresh dry land units were brought down and grown under irrigation and propagated the following season, or seasons. Each time the fresh dry land potatoes greatly out-

yielded the irrigated and the units irrigated two years. Lots irrigated two years yielded 22.5 per cent of dry land stock, those irrigated one year yielded 42.1 per cent as much as dry land potatoes.

TABLE II

Triumph Potatoes, Minatare, Summary 1918-1920. Total Yield of Potatoes. Total Pounds Per Acre

Year	Irrigated two years	Irrigated one year	Dry land
1918	7,531	. . .	24,200
1919	. . . .	6,500	16,590
1920	1,973	8,270	17,944
Mean 1918-1920	4,752*	. . . .	21,072
Mean 1919-1920	. . . .	14,770†	17,267

*22.5 per cent of dry land †42.1 per cent of dry land

Marketable Yield Per Acre, Pounds

Year	Irrigated 2 years	Irrigated 1 year	Per cent of total	Dry land	Per cent. of total
1918	6823	.	90.6	23,513	97.1
1919	. .	5034	77.4	11,983	72.2
1920	800	4194	51.3	11,052	61.6
Mean 1918-1920 3,811.5 (22.04 per cent. of dry land				17,282.5	
Mean 1919-1920 4764 Lb. (41.3 per cent. of dry land				11,517.5	

throughout the period (See Table 2). Lower yields in 1919 and 1920 are due to poorer care of the field.

The consistency of these results each year is very significant. Disease had not been the factor. The various units were uniformly practically free from disease. None of the physiological diseases have been present to cause variation. A few of the very weak units may now have some of these diseases, but the diseases quite surely did not cause their degeneration, they evidently have come in after degeneration was well advanced. Probably the irrigation practiced on this farm is heavier than that prevalent throughout the region. That may partly account for these marked results.

In 1920 at Morrill, Nebraska, also under irrigation, were planted 6 varieties of potatoes. In 1919, seed of each of these varieties was grown at each of 4 dry land and 4 irrigated places in western Nebraska. The original seed of each variety for each point was from the same source. In the fall of 1919, representative seed tubers were assembled at Morrill from each variety at each trial point. They were planted under exceptionally uniform conditions and were given the best of care all season. In Table 3 are

TABLE III

Comparison of Effect of Dry Land Culture and Irrigation Upon Seed Potatoes at Morrill, Nebraska. 1920. Total Yield Bushels Per Acre.

Variety	Mean of seed from four dry land places bushels	Mean of seed from four irrigated places, bushels	Gain from dry land seed, bushels
Russet Rural New Yorker ..	508.6	454.9	53.7
King	321.2	451.5	69.7
Triumph	347.1	312.7	34.4
Irish Cobbler	448.4	332.5	115.9
Downing	446.7	400.8	45.9
Pearl	577 4	406.9	170.5
Mean	473 0	392.7	80.3

given the averages of yields secured from the seed from the dry land and from irrigated places in the case of each variety. In every variety the one year of irrigation had some effect on the seed tubers, and the net difference for all varieties was 80.3 bushels per acre in favor of dry land seed. Results of one year are not always reliable. These are given because of the number of lots of potatoes involved and the similarity of the Minatare results.

Similar results were secured at two other trial points with other lots of seed. The results will not be given here.

These data indicate that the conditions produced by irrigation as practiced in the west have a very markedly deleterious effect upon tubers for seed purposes, which is manifest after the first season. Disease has not been a factor in this work. Irrigation has been the only factor that can be considered responsible for the differences secured. Dry land grown seed potatoes are distinctly superior. Marked degeneration may take place without the prevalence of any diseases known at present.

From previous results of other workers and these results it is quite plain that fundamental tuber unit studies with potatoes can throw little light on the fundamental principle of tuber line selection, unless the work is carried on where atmospheric, soil, and moisture conditions, are all satisfactory for normal development of potatoes. It is likewise important to guard against disease infecting the trial seed stock.

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Effects of Nitrate of Soda on the Nutrition of the Tomato

By PAUL WORK, *Cornell University, Ithaca, N. Y.*

A STUDY of the records of fertilizer experiments with tomatoes some years ago revealed the need of a critical examination of the influence of nutrient materials in the growth and metabolism of the plant. In most of the field experiments repetitions and checks have been insufficient and so many variables have been involved that definite conclusions could seldom be drawn with assurance. At best the results have represented a statement of what might be expected under a repetition of the conditions of the experiment. Few principles of general application could be adduced.

The study here reported has been confined to the influence of nitrate of soda. In the attempt to eliminate as far as possible all other variables it was deemed necessary to abandon the well-nigh infinite complexity of weather and soil that prevail in the field, in favor of the more complete control of sand culture in the greenhouse. Even so the worker often finds that one or more of the new and somewhat artificial conditions, while uniform, is not sufficiently favorable to afford the plant its full development. The growth curve may be cut off before the variable factor which he is studying has had opportunity to exercise its full effect, and its influence in the later stages of the history of the plant may remain unknown.

The three-fold aim of the present study may be stated as follows:

1. To grow the plants under conditions such that the amount of nitrate of soda applied to the soil would vary through a definite series, and the other factors for growth would be provided in uniform and favorable excess.
2. To record in great detail the performance of the plant, using quantitative measures as far as possible.
3. By means of chemical analysis to throw some light on the conditions existing within the plants that had been subjected to the various treatments.

In each of the two experiments reported, 75 plants were grown singly in boxes containing about a bushel and a third of quartz sand. There were five to eight duplicates and the treatments are indicated in Table 1. Other nutrients were supplied in what was judged to be uniform and favorable excess. Moisture was controlled and leaching eliminated by weighing the boxes twice a

*This paper is an informal report on a study, the full data of which are still unpublished. The work was done at the University of Minnesota under the guidance of Dr. L. I. Knight.

week and supplying the water necessary to bring them back to standard content.

Plant Performance

Data were taken on ten different measures of plant performance. The curves, twenty in number, are strikingly similar in general trend. In all but one (green weight of tops) of the ten measures, the maximum is reached at treatment F, (32 grams per box). In the summer experiment, the decline is fairly marked from F to G (64 grams) and then is very gradual. In the autumn experiment the decline from F is very slight.

Table I

Amounts of Nitrate of Soda Applied to Boxes in Treatment-Sets Experiment VI (Summer) and VII (Fall)

COLUMN

1 Boxes receiving identical treatment constitute "treatments." A-J and P-K-R are called "series." Capital letter designations hold for both experiments.

3 Calculated on area of sand in boxes. Depth about 12 inches.

4, 6 Calculated on amount of dry soil to fill a box. Experiment VI, Ottawa sand, 140 pounds per box. VII, Wausau sand, 110 pounds.

5, 7 Calculated on moisture content to which sand was brought at each watering. Ottawa carried 7.5 per cent or 10.5 pounds. Wausau, 16.37 per cent or 18 pounds.

1	2	3	4	5	6	7
			Experiment VI		Experiment VII	
Treatment sets	Nitrate grams per box	Pounds per acre	Per cent on soil	Per cent on moisture	Per cent on soil	Per cent on moisture
A	.0	....	....	....	....	....
B	.5	35	.0008	.011	.0010	.006
C	2	141	.0032	.042	.0040	.025
D	8	564	.0126	.168	.0161	.098
E	16	1128	.0252	.336	.0321	.196
F	32	2256	.0504	.672	.0642	.392
G	64	4512	.1008	1.344	.1283	.784
H	128	9024	.2016	2.688	.2566	1.568
J	256	18048	.4031	5.375	.5131	3.135
		Two applications 9 weeks apart				
L		8-0-0-8	See D and E above			
		Four applications 3 weeks apart				
P		2-2-2-2	See C and D above			
K		8-8-8-8	See D and F above			
R		16-16-16-16	See E and G above			

Time fails for a description of the behavior of set L which grew well for a few weeks, then showed marked symptoms of starvation until it received its second feeding, when the plants made a most vigorous response in both vegetation and fruition. This responsiveness of the tomato makes it a most excellent plant for nutrition studies.

Data from Series P-K-R showed clearly that a given amount of nitrate is more effective in several applications than in one.

Heavy applications of nitrate, up to 9 tons per acre, did not bring about a condition of high vegetation and unfruitfulness, nor did soil containing about 1/3 of well rotted manure.

Data on height of plants, on fruit-making and on water used, were taken in order that their usefulness as records of plant performance week by week might be studied. With data that involve only the total performance and the final state of the plant, our picture of its history is pitifully incomplete.

We have not yet found any single measure that tells the whole story of plant behavior. Height, like others, when considered alone, is fragmentary as it represents but one dimension in three dimensional growth. Also plants beginning to suffer nitrogen hunger have a tendency to spindle out. Yet the curves hold closely to the others and offer at least a rough sketch of what happens during the progress of plant growth.

While amount of water used varied with atmospheric conditions as well as with leaf area and plant activity, and so is of doubtful value as a measure, yet there are marked apparent correlations between these data and those derived from other measures.

It is noticeable that the number of buds per blossom rises while the number of blossoms per fruit falls with increasing applications of nitrate. However, undue weight should not be placed on such deductions as each of these processes of development represents more than one step, each governed by a more or less distinct set of conditions. A numerical ratio does not necessarily represent a causal relationship. Such data, however, may be of value in suggesting steps in the whole process of fruit making, each of which should be subjected to investigation on its own merits as well as in groups. Among these steps may be mentioned laying down of floral primordia, development to maturity of the blossom, including the development of pollen and egg cells, pollination, fertilization, and the subsequent development of fruit.

Plants in set F (32 grams) were quite consistent in showing a period of fruitfulness at the beginning followed by a failure to blossom and set fruit for a time. This in turn was followed by a new period of fruit-making, until the supply of plant food in the soil was presumably exhausted. Such behavior raises a world of questions as to the relation of internal conditions to one another and to performance. Does the bringing on of fruits already set prevent blossoming and setting in other clusters? If so, what is the chain of causes by which this is occasioned?

Chemical Data

In examining data from chemical analysis, we seek to gain some idea of the internal conditions that correspond to treatments applied on the one hand and to external expressions of growth and reproduction on the other. Such data are of real value for the purpose, but we must remember certain very serious limitations:

1. We ordinarily analyze a bulk of plant material including

many structures of varying nature and function. Thus only conditions that are conspicuous in the economy of the plant are likely to be revealed. At this point micro-chemistry may well enter, though we shall doubtless always face the vast difference between what happens in the chemical laboratory and what happens in the living plant.

2. The relations of cause and effect are often most complicated and more often indirect than direct. Nor is the time element absent. Today's behavior may result from a condition of a week ago which has now passed. In this connection we must seek to adapt to our problems methods of analysis which can be carried out with small samples, taken week by week, without seriously injuring the plant. In this manner we may be able to build up a running story of the internal conditions that prevail within the plant.

TABLE II

Treatment—Sets in Order of Nitrogen Content of Leaves. Percentage on Green Weight Basis. Treatments in Grams Per Box.

Treatment-sets*	Treatments	Performance†		N	CH	CH/N
Y	Young plants	V	‡	.390	.366	9.38
LN-VI	8-0-0-8	V	P	.378	2.39	6.32
	New growth					
X	Not in					
	Experiments	V	NP	.372	1.20	3.23
LA-VII	8-0-0-8	V	P	.354	.92	2.57
	After 2d Application					
R-VII	16-16-16-16	V	MP	.341	1.30	3.81
J-VI	256	NV	NP	.334	1.81	5.48
X-VII	8-8-8-8	V	P	.324	1.49	4.60
J-VII	256	V	P	.320	1.44	4.50
K-VI	8-8-8-8	MV	NP	.314	1.34	4.27
			RP			
P-VII	2-2-2-2	MV	MP	.256	1.92	7.50
			RP			
E-VI	16	NV	NP	.232	5.97	25.73
LO-VI	8-0-0-8	—	—	.222	1.94	8.74
	Old growth					
F-VII	32	NV	SP	.192	1.43	7.45
			BP			
N-VI	Soil and	NV	NP	.190	2.54	13.37
	manure	RV	RP			
LB-VII	8-0-0-8					
	Before 2d Application	NV	NP	.156	1.43	9.10
A-VI	0	NV	NP	.138	4.62	33.48
A-VII	0	NV	NP	.132	3.65	27.65

*Letters refer to treatment—see Table I. Roman numerals are experiment-numbers. VI was conducted in the summer of 1920, VII in the fall.

†V=Vegetative N=Non- R=Recently
P=Productive S=Slightly B=Becoming
M=Moderately

‡Not yet productive, but rapidly becoming so.

While dry weight is doubtless the best measure of plant product, the green weight basis better represents the conditions of

metabolism existing in the plant at a given moment, and is accordingly used in the main. Also leaf material receives major attention as representing the great workshop of plant metabolism while the stems are engaged primarily though not exclusively in transportation and storage.

Nitrogen

While the nitrogen content (Table 2) of both leaves and stems shows a distinct rise with increasing applications of nitrate, it is not believed that this represents a direct causal relation, but rather that it expresses successive stages of nitrogen exhaustion. 1. The young plants as set, having grown in greenhouse soil, showed the highest nitrogen content of all. 2. Vegetative plants show nitrogen contents above .3 per cent whether they have had applications of 256 grams or 8 grams of nitrate. 3. Low nitrogen plants all gave external evidence of advanced starvation, while intermediate figures were associated with plants that seemed to have entered upon such a decline.

No vegetative set (considering the conditions at the time of sampling for analysis) showed a nitrogen content below .3 per cent. The same holds for fruitfulness.

The question at once arises as to how the shortage, or the surplus of nitrate applied, achieve their injurious effects. No experimental data are offered as to deficient supply, but our knowledge of the nitrogen compounds of the plant and their roles would seem to indicate that it is probably through lack of this element for the synthesis of proteins rather than through the lack of chlorophyll making.

Three lines of evidence from the main experiments and several sub-experiments support the hypothesis that an excess of nitrate applied injured through its effect as an osmotic agent rather than as an active plant poison—as an environmental factor rather than through its effect in plant metabolism. 1. Injury, including wilting as well as stunted growth, was much more conspicuous in the summer than in the fall experiment, the former being under high temperature, abundant sunlight and rapid evaporation. 2. Blossom end rot, recognized by growers and shown experimentally by Brooks to be at least partially a drouth trouble, was more prevalent in the summer and was checked when the water content of the sand was increased. 3. The calculated concentration of nitrate in the soil solution was well above the concentration found necessary to injure and even kill in water solution and in small crocks of sand. This line of reasoning does not preclude the possibility of the sodium ion acting as a toxin.

Carbohydrate

High carbohydrate content (Table 3), occurs in most though not all starved plants. The range from .92 per cent to 3.66 per cent seems to show plants in all categories of vegetation, fruitfulness and nitrogen content. Thus, barring the starved sets, there

appears to be little if any correlation between this factor and plant performance. This is hardly suprising when we consider that carbohydrate content represents a balance resulting from the opposing forces of manufacture and use, the lattèr really involving many processes—respiration, formation of structural parts, and synthesis of other plant materials as proteins, glucosides and others. Further, we do not know precisely to what extent each of these uses, barring the first, removes the compounds from the scope of our methods of analysis; that is, of the more or less arbitrary degree of hydrolysis adopted in any study. Moreover, each of the processes of use may vary more or less independently of the others.

The fact that the lowest carbohydrate content was found in a very active set of plants would suggest that the requirement of the plant has been met whenever the rate of manufacture exceeds the rate of use by only enough to insure the presence of a quantity sufficient to keep the machinery going. How much lower than .92 per cent this could be, remains to be shown. To illustrate this

TABLE III

Treatment-Sets in Order of Carbohydrate Content of Leaves. Percentage on Green Weight Basis. Treatments in Grams Per Box.

Treatment-sets*	Treatment	Performance†		CH	N	CH/N
E-VI	16	NV	NP	5.97	.232	25.73
A-VI	0	NV	NP	4.62	.138	33.48
Y	Young plants	V	‡	3.66	.390	9.38
A-VII	0	NV	NP	3.65	.132	27.65
N-VI	Soil and *manure*	NV RV	NP RP	2.54	.190	13.37
LN-VI	8-0-0-8 *New growth*	V	P	2.39	.378	6.32
LO-VI	8-0-0-8 *Old growth*			1.94	.222	8.74
P-VII	2-2-2-2	MV	MP RP	1.92	.256	7.50
J-VI	256	NV	NP	1.81	.334	5.48
K-VII	8-8-8-8	V	P	1.49	.324	4.60
J-VII	256	V	P	1.44	.320	4.50
F-VII	32	NV RV	SP RP	1.43	.192	7.45
LB-VII	8-0-0-8 *Before 2d Application*	NV	NP	1.43	.156	9.10
K-VI	8-8-8-8	MV	NP RP	1.34	.314	4.27
R-VII	16-16-16-16	V	MP	1.30	.341	3.81
X	Not in experiments	V	NP	1.20	.372	3.23
LA-VII	8-0-0-8 After 2d application	V	P	.92	.354	2.57

*Letters refer to treatment—see Table I. Roman numerals are experiment-numbers. VI was conducted in the summer of 1920, VII in the fall.

†V=Vegetative N=Non- R=Recently
P=Productive of fruit S=Slightly B=Becoming
M=Moderately

‡Not yet productive, but rapidly becoming so.

point, we cannot judge the rate of cloth making in a cotton mill by the number of bales of raw cotton found in the factory. The work can go ahead as rapidly with five bales in the warehouse as with five hundred.

Young plants as set at the beginning of the experiments were in a thoroughly active condition as regards vegetation, and they went on in fruit-making no matter what treatment they received in the boxes. So they may be regarded as vegetative and productive and they show the third highest carbohydrate content of all. There is no indication that such a content is injurious. Nor would we expect carbohydrates in their ordinary forms to be deleterious in view of their universal presence and their high concentration in certain parts and at certain times. It would seem more probable that the high carbohydrate concentration found in those of the plants that have ceased activity should represent an accumulated excess stored up after utilization in fruit-making and vegetation had ceased through lack of nitrogen, but before photosynthesis was wholly at an end.

Nitrogen-carbohydrate Relation

Much attention has been devoted of late to the relation between nitrogen and carbohydrate contents as factors or a factor in plant metabolism. We owe much to Klebs for the development of the concept that external conditions acting by means of their modification of internal conditions, have much to do with the way in which the plant shall express the hereditary possibilities that lie within it. While this most persistent worker has recognized and discussed many of the possible internal factors involved, it has remained for Kraus and Kraybill to focus the light of extensive chemical evidence upon the questions involved. These workers found that as carbohydrate content falls, nitrogen content rises, and that "fruitfulness is associated neither with highest nitrates nor highest carbohydrates, but with a condition of balance between them"; further, that "very large proportional reserves of carbohydrates to moisture and nitrate supply also accompany decreased vegetation." Their results, much broader than these fragmentary statements can indicate, are interpreted by Crocker in terms of C/N $\left(\frac{\text{carbon}}{\text{nitrogen}}\right)$ ratio, a concept advanced by Hugo Fischer. Gurjar in a paper published only in abstract states that the "Vegetative prosperity of the plant (tomato) stands in inverse relation to the C/N $\left(\frac{\text{carbon}}{\text{nitrogen}}\right)$ ratio."

The data of the studies here reported do not reveal a rise in nitrogen content corresponding to a decline in carbohydrates, (Tables 2 and 3). When two factors play as complex and various parts in plant metabolism as do these, it is hardly to be expected that their relation to each other may be expressed in a simple mathematical ratio. This would imply that the two are interdependent variables and that together they constitute a factor

which conditions the activity of the plant—in this case in vegetation and reproduction. Such a concept would hardly be in accord with the concept of successive limiting factors. Let us assume a plant so situated that all factors for its activity are present in favorable excess except nitrogen and carbohydrates. Let nitrogen be available in an amount sufficient to permit half the growth of which the plant is capable. With carbohydrates absent, there will be no response. Now let carbohydrates become available in successive increments. We may expect the plant to respond in proportion to these increments, until a point is reached such that the nitrogen available is fully utilized. Further increments of carbohydrates will continue to change the ratio, but will be no service to the plant and it will not respond further. Assuming now that carbohydrates have become available up to the full need of the plant increments of nitrogen will be effective in proportion to their amount until the plant has attained its maximum possibility. Thus, in general, it would seem that plant performance is to be related not to the ratio between two possible limiting factors, but to the available amount of the single factor that is in minimo at the moment.

This line of reasoning does not preclude the possibility of two interdependent conditions together constituting a limiting factor, nor does it preclude the possibility suggested by Kraus and Kraybill that a change from one relationship of vegetation and fruitfulness to another, may be associated with a change in the carbohydrate-nitrogen relationship. The amount of any single factor necessary for the full development of a part or function doubtless varies widely for different materials, for different uses of those materials and for different plant species.

An examination of the data of this study suggests the following statement as probably valid for the nitrogen-carbohydrate relationship existing under the conditions of the experiments recorded.

With no nitrate applied to the soil, as in sets A VI and VII (O),* plants grew and fruited to a very limited extent—as far as the nitrogen already in the plants at the time of setting would permit. Chlorophyll already existing or made from nitrogen present, was sufficient for the manufacture of a considerable quantity of carbohydrates. This being unused through lack of nitrogen, was stored and appeared in high concentration on analysis of the plant tissue.

A small amount of nitrate, as in sets D VI (8) and P VII (2-2-2-2) was sufficient for limited growth and fruiting. Plants from P only were subjected to analysis. An amount of nitrogen smaller than is associated with vigorous vegetative growth (.3 per cent plus) was found with a medium concentration of carbohydrate. It is entirely possible that the nitrogen content had been above .3 per cent and that at the time of sampling it had fallen in the absence of an available supply. Carbohydrates had been used

*Figures in parenthesis indicate amounts of applications of nitrate. See Table I.

pretty much as made and there had not been opportunity for large accumulation.

Early and large applications of nitrate, as in sets J VI and VII (256), or late moderate applications, as in LN VI and LA VII (8-0-0-8), K VI and VII (8-8-8-8), and R VII (16-16-16-16), occasioned a nitrogen content in the plants sufficient for vegetative activity and for fruit making. Plants were still active at the time of sampling with the exceptions of J VI, which suffered from the ecological effect of the high application of nitrate and K VI, which was moderately vegetative and had recently been fruitful. This latter exception is unexplained. Carbohydrate content in these varied materially according to the balance between manufacture and use. Both of these processes, in the presence of sufficient nitrogen, would be dependent upon many factors that were not controlled and on which observations were not taken. Among them may be mentioned light, as to quality and intensity, reaction (hydrogen-ion and titrable acidity), enzym action, and others. The recent studies of Garner and Allard would suggest that the first mentioned may have been a potent factor, especially toward the close of the fall experiment (VII). While all boxes were similarly exposed, the influence of a given quality and intensity of light may conceivably have varied under the different experimental treatments.

The plants under early moderate treatments as E VI (16) and F VII (32) made excellent growth for a while, but at the time of analysis, had apparently consumed most of the available nitrogen, and had declined materially in activity. The nitrogen content of the plants was correspondingly low. E VI was nearly dead and the carbohydrate content was the highest recorded, while F VII was in an earlier stage of decline and carbohydrate accumulation had not progressed very far. In the light of the behavior and nitrogen content of LA, LN, K and R, we may well suppose that the nitrogen content of E VI and F VII had been above .3 per cent when they were in the prime of their activity. All of which makes very clear the desirability of analyses of successive samples from the same plants as they pass, under controlled conditions, from one stage of activity to another.

Notes on Spinach Breeding

By Loren B. Smith, *Virginia Truck Experiment Station, Norfolk, Va.*

THERE are between four and five thousand acres of spinach grown each year in the eastern Virginia trucking section. The shipments of this vegetable from the port of Norfolk, according to the reports of the various transportation companies, for the fourteen year period, 1905 to 1918, amount to an average of 632,317

barrels each year, and are valued at $1,000,000 to $1,500,000. For the past twenty years the spinach crop in this region has been seriously affected by a mosaic disease known locally as "Blight" or "Yellows." It has been estimated[1] that this disease destroys 20 per cent of the crop annually. It was not until early in the year 1916 that the infectious nature of this disease was discovered. Previously it was supposed that it was caused by nutrition troubles. The only means of transmitting the disease from plant to plant in the field that has thus far been found, is through the agency of insects, particularly two species of aphids.

With the discovery that spinach "Blight" belonged to the mosaic group of diseases, work was immediately begun on the breeding of a variety which would be resistant to the malady. Previous studies of certain strains together with the assistance and cooperation of Mr. J. B. Norton, formerly Plant Physiologist, United States Department of Agriculture, aided materially in getting the problem quickly and successfully started. By a fortunate selection of parent stocks the resistant[2] factor has been well established in various lines of hybrids. The varietal name which has been given to the mosaic-resistant stock is "Virginia Savoy" of which there are several strains. Over 500 pounds of this seed were produced at Virginia Truck Experiment Station in 1920. Some of this will be grown under contract by seed growers, which should give a supply for a wide local distribution among the Virginia truck farmers in the autumn of 1921.

This paper comprises in brief form a resume of the methods used in the production of a mosaic-resistant spinach, together with a discussion of some of the more important characters to be considered when breeding improved strains.

Parent Stocks

The Savoy spinach is the only type desirable for the eastern Virginia trucker to grow under present conditions. Practically all of the spinach grown in this region is shipped to northern markets which necessitates a two to five day haul. The crop is packed in veneer barrels which contain 45 to 55 pounds net. The crumpled, thick savoy leaves act as more or less of a cushion and when the barrels are unpacked the plants quickly resume their normal shape. Aside from this, the Savoy spinach is an excellent sort for growing during cold weather, and when healthy holds its color well throughout the entire growing season. In beginning the breeding work, all the more important strains of Savoy together with many American and foreign varieties of spinach, were grown for the purpose of testing their susceptibility to mosaic. Only one variety was obtained which showed any marked resistance to the disease. This one is known as Manchuria, and is the offspring

[1]McClintock, J. A., and Smith, Loren B. True Nature of Spinach Blight and Relation of Insects to its Transmission. Journal of Agricultural Research, Vol. XIV, No. 1, 1918.

[2]The term "Resistance" is used in this paper in its broadest sense and is qualified by degree. It should not be taken as referring to a complete unsusceptibility to the disease.

of plants grown at Concord, Massachusetts, by Mr. J. B. Norton from seed sent to the Office of Seed and Plant Introduction by the late Frank N Meyers, who obtained it in northern China and Manchuria. In comparing these plants with original descriptions of the wild European spinach, it is probable that the variety which was sent to this country by Meyers is the native wild spinach of Asia which has adapted itself to the colder regions of Manchuria. The seeds are moderately large and very spiny. The plants are slow growing, will withstand the coldest weather occurring in eastern Virginia, and are not susceptible to mosaic unless artificially inoculated. They also possess a quality which is distasteful to aphids and only in rare instances are these insects found abundantly on these plants. The leaves are smooth, long, width not over one-third of the length, usually less, and are deeply four or five lobed. The petioles are moderately long, usually two to four inches, and are distinctly purple, which color usually extends about one-half the distance along the leaf margins. The plants are heavy bearers of seed which matures about one week later than the Savoy varieties.

All the early crosses were made between the Savoy and Manchuria and later the Round-Leaf and Thick-Leaf types have been crossed with the hybrid stock in order to bring in new factors in color, thickness, shape of leaves, and habit of growth of the plants. The varieties used particularly for this purpose were the Round Thick-Leaf Winter, Viroflay, Flanders, and Long Standing.

Mosaic Resistance

The Manchuria spinach has been found to possess a resistance to mosaic in the proportion of one case of mosaic in 10.500 plants grown. From this parent has been developed the resistant factor in the present hybrid stock. Not only is this parent resistant to the disease, but it is not as attractive to aphids as a source of food as other varieties. This has been demonstrated repeatedly under greenhouse, field cage, and field conditions. The hybrid stock is also much less heavily infested under unusual conditions than is the commercial Savoy spinach. In October, 1917, a three acre field was planted with one of the best strains of commercial Savoy in alternate beds with F_3 Manchuria hybrid stock. The plants in a block ten feet wide, extending laterally across the field, were examined in February, 1918, and the infestation of aphids determined with the following results:

1261 Savoy Plants

	Number of plants	Per cent of total number of plants
Infested with the potato aphis (*Macrosiphum solanifolii*, Ashm)	1179	93.5
Infested with the spinach aphis (*Myzus persicae*, Sulz.)	395	31.3
Uninfested by aphids	41	3.2

1305 Manchuria Hybrid Plants

	Number of plants	Per cent of total number of plants
Infested with the potato aphis (*Macrosiphum solanifolii*, Ashm)	342	26.2
Infested with the spinach aphis (*Myzus persicae*, Sulz.)	321	24.5
Uninfested by aphids	902	69.1

In this case the spinach aphis shows less selectiveness in its choice of varieties than does the potato aphis. This can probably be ascribed to the difference in activity of the two species of aphids. The infestation of these plats was light, and the aphids caused no visible degree of injury to the crop. During periods favorable for the development of aphids, the Manchuria hybrid stocks may become as heavily infested as other varieties. While the preference of aphids for other varieties of spinach may to some extent account for there being less mosaic in the hybrid strains, a large amount of data collected on this phase of the subject indicates that the resistance is due to physiological, or possibly morphological, conditions in the plants, rather than to absence of inoculation.

The selection of mosaic resistant plants was conducted on the basis of the number of affected plants in the lot. In order to determine the amount of mosaic likely to occur, small lots of Savoy seed were planted in the fields with the hybrid stock and counts made of the number of mosaic affected plants developing in them. These lots were cut before seeding time. As a matter of course, plants from the strains showing the least amount of mosaic were selected for crossing. However, in order to obtain and develop certain characters it was necessary to use individuals from less resistant strains. An arbitrary standard was decided upon as a limit in the utilization of strains developing susceptible tendencies. As soon as a strain developed more than two per cent mosaic plants, it was discarded, and also no plants were selected from strains in which the proportion of diseased plants exceeded 1 to 10 when compared with the number of diseased plants in the Savoy lots used as controls. This system has proven effective as shown by the constant improvement in resistance in succeeding generations of the hybrid stocks. The following tabulated statement of the number and per cent of hybrid plants affected with mosaic and the ratio between these and the amount of mosaic in the Savoy lots, illustrates this point. These figures were taken from selected stocks planted each year for the purpose of comparison.

Generation	Feet of bed	Number of plants	Affected with mosaic	Per cent mosaic	Ratio of blighted plants in hybrid stock to those of Savoy
F_2	550	5,000	317	6.14	1 to 4.35
F_3	1,000	10,200	537	5.26	1 to 8.41
F_4	2,400	24,000	506	2.10	1 to 12.20
F_5	11,100	100,000	646	0.64	1 to 16.37

Size

This is usually measured by the width and height of plants when the maximum growth is reached. This occurs just previous to the development of the seed stalks. The height is the distance between the crown and the highest point on the plant, which in desirable individuals should be the tip of one of the young, entirely green leaves. The width is considered the distance between the tip of the largest leaf to the tip of the leaf opposite when they are gently straightened out to their full extent. Other necessary measurements for size are the length of the petiole and midrib, and the greatest width of the largest leaf. In a general sense the size which the plants attain is a matter of nutrition, especially with a species as susceptible to the morphological variation through differences in fertilization as spinach.

Strains of hybrids were developed which vary considerably in rate of development and time of maturity. In order to obtain a strain able to withstand considerable cold weather and which would be marketable during January or February, it was necessary to use the factor of size very largely in the selection of parent stocks. It has been found that by crossing the Manchuria hybrids with one of the Long Standing varieties, the offspring when planted in the autumn develop somewhat less rapidly at first, than either parent. Their growth, however, is more continual, and is not checked as soon by adverse weather conditions. As a result, when the market conditions are such that it is desired to hold a fall crop for cutting in January, February, or March, this strain will give a large yield of the very finest quality spinach, when Savoy strains will produce a crop yellowed from being checked in growth and showing injury to many leaves from wind and cold. In order to select a winter spinach, it is necessary to have accurate records of size several times during the autumn and early winter, and particularly just before the spring growth commences. Measurements of size were taken with a steel rule graduated to sixty-fourths of an inch.

Savoying

This refers to the excessive development of tissues in the spaces between the leaf veins. Originally applied as a varietal name of a cabbage grown extensively in the province of Savoy, France, its

use has been extended until it is now a descriptive term used to designate this characteristic leaf development on other species of plants.

Savoying should extend uniformly over the leaf and the interspaces should be developed to an extent which does not permit the veins being seen when looking toward the upper surface of the leaf. Certain plants develop what may be termed a crumpled leaf, in which the area between the lateral veins is not as deeply savoyed as are the main veins. This type is undesirable, since, when pressure is applied to the leaf, it is likely to break along the lateral veins.

In determining the savoy factor of a leaf several measurements were necessary. Inasmuch as savoying increases the leaf area from that of a smooth leaf within a given perimeter, the amount of savoying may be termed the percentage increase in leaf area of a savoyed leaf over the leaf area of a smooth leaf having the same perimeter. When making the determinations for individuals, two perfect mature leaves were selected from each plant. These should be between the seventh and twelfth leaves in order of development and must be savoyed typically from the standpoint of the plant from which they are taken. The petiole was removed at the base of the leaf. The leaves were then weighed to hundredths of a gram. The thickness of each leaf was then determined by means of micrometer measurements of the areas between the veins. Ten or more measurements were taken for each leaf and an average taken as the final result. We have found the starrett micrometer graduated to $\frac{1}{2500}$ inch and fitted with a ratchet, to be satisfactory for this purpose. By regulating the ratchet to slip before pressure enough is applied to break the leaf tissues, uniform pressure is applied to each leaf and the determinations can be rapidly and accurately made. The area of the flat surface enclosed by the perimeter of the leaf was measured with a polar planimeter. A box two feet square containing an electric light was fitted with a plain glass top. The leaf was laid on this glass with the top of the leaf toward the light. A ground glass, with the etched side up, was supported over the leaf in a position which brought the leaf margins in contact with the glass, but did not cause the leaf to flatten or spread out. The margins of the leaf could then be accurately traced with the plantimeter on the surface of the ground glass, and the area enclosed by the perimeter of the leaf thus obtained. With these measurements the increase in leaf area due to savoying was determined as follows:

Let P = measured flat area enclosed by perimeter of the savoyed leaf. W = weight of leaf. T = thickness. A = calculated or true area of the leaf. Y = per cent increase in leaf area as a result of savoying.

Then

$$A = \frac{W^*}{T}$$

$$Y = \frac{100\left(\frac{W}{T} - P\right)}{P} = \frac{100\ (A-P)}{P}$$

In order to derive the savoy factor in terms of a comparison between a smooth leaf and savoyed leaf having similar perimeters, the second formula was necessary. In this the flat area P enclosed by the perimeter of the savoyed leaf was taken as the area of a flat leaf. Then area P was deducted from A, the calculated area, and expressed as Y, which was the percentage increase in leaf area which resulted from its savoyed character.

Color

The color or the shade of green of spinach is variable, difficult to measure and yet one of the more important factors from the standpoint of the grower. It is desired to obtain a very dark shade, and one which has not over 7 per cent of blue in its color composition, is ideal. The advantage in obtaining a strain of this color type is that when cutting is delayed, as it often is for several weeks, or even months during the late autumn and winter on account of slow growth of the crop or weak markets, there is a tendency for the leaves to assume a yellowish-green color which is discriminated against in the markets. Also when plants in the early stages of mosaic are cut and shipped, the yellow color increases during transit and lower prices are often obtained as a result of a small percentage of these affected plants being included

*The formulæ are derived as follows:

$$\text{Density} = \frac{\text{Weight of Mass,}}{\text{Volumn}} \quad D = \frac{W}{V}$$

then

$$V = \frac{W}{D}$$

In the consideration of spinach the density is so close to that of water that for purposes of comparison it may be considered as unity or 1.

Therefore

$$V = \frac{W}{I} \text{ or } V = W$$

Also

$$\text{Volumn} = \text{Area X Thickness, } V = A \times T$$

and since

$$V = W$$
$$W = A \times T$$

whence

$$A = \frac{W}{T}$$

which is very close to the actual area of the savoyed leaf.

in a shipment. The harvesting of plants possessing the blue-green character may be postponed for a much longer period than can the harvesting of pure green plants before any yellowing appears, and when the former type is affected with mosaic, the early symptoms are much delayed in their appearance. This does not indicate any degree of resistance since the late symptoms appear in the blue-green strains with a correspondingly greater degree of rapidity than in the pure green lines, and one will die as quickly from mosaic as the other.

The measurement of the color factor is difficult owing to the fact that there are several physiological conditions having no direct relation with the color constitution of the plant, which may influence the shade of its leaves Weather conditions have a marked influence on the color of the plants as do the kind and amounts of fertilizers used, and the conditions under which they are applied. The color tendency, if the term may be used, is inheritable, and can be greatly increased by breeding. This factor was measured altogether by a system of comparison and scoring. When scoring strains or individuals, the darkest and lightest colored healthy individuals were selected and staked. These were then given ratings of 0.01 and 0.09 respectively Seven other plants which had colors graduating between the two extremes were used as standards for the numbers 0.02 to 0.08 inclusive. By comparing other plants with the standards, a fairly accurate, comparative measure of color, could be obtained. As far as possible, color selections were made on cloudy days and the standard plants were checked, and changed if necessary, each day that selections were to be made. That the scorings made at various times during the season are comparable is indicated by the fact that in only one season has it been necessary to change the most desirable plant (0.01) in the standard, and then it was interchanged with the standard plant for the score 0.02. The greater number of changes occurred in the standards among the plants of poor color, or those scored 0.06 to 0.09. In rare cases only were plants scoring this low in color used for breeding, and the few changes influenced the comparableness of the data very little. Color variations are greatest and are least likely to be influenced by conditions outside of the constitution of the plant when the maximum growth has been made previous to the development of the seed stalk. All scores of the color of individuals made earlier in the season were checked at this time. In determining the color factor of strains, several hundred individuals were scored in this manner from each strain, and the mean score for each lot taken as its factor.

Thickness of Leaves

This character, like savoying, is desirable from the standpoint of adding strength to the leaves thereby enabling them to withstand shipment and arrive at market in a better condition than those which are thin and flacid. The thickness of the leaves was measured by means of a ratchet micrometer. Except in the strains bred for long-standing qualities the thickness of the leaves should

be determined before warm weather in the spring, which in the region of Norfolk, Virginia, is usually between March 10th and 25th. Mature leaves between the seventh and twelfth in the foliation should be used. Measurements were taken of the tissues in the interspaces of the veins. Several determinations were made on each leaf and the average taken as the factor for the plant. This is an exceedingly variable character. Extremes in thickness of .2438 to .9956 mm. have been noted during the work.

Closeness

The closeness of the foliation is dependent upon the length of the petioles. It is desired to obtain a great length of leaf with a short petiole. A figure which will denote the degree of closeness of a plant is derived by dividing the width of the plant by twice the length of the longest petiole.

Shape of Leaves

Originally spinach leaves were ovate, sagittate, or pinnately lobed in form. In present varieties this is one of the more variable characters and the most difficult to control from the standpoint of the plant breeder. In the Manchuria hybrids the leaves should be reclined but not recurved or recumbent. The width of the leaf blade should not be less than three-fourths of the length, the margins undulate and reclined with a slit-like cleft on either side near the base. The tip should be broadly obtuse and conform in position to that of the leaf. In the selection of individuals only those plants which had these leaf characters were used. The improvement in strains was noted in the percentage of plants conforming to type. All plants whose leaves are distinctly offtype were rogued before any other character determinations were made. While this may appear stringent, nevertheless it is the safest, and in the long run the quickest, method of fixing type. Many commercial varieties and especially those of Savoy type do not have more than 60 per cent of the plants typical of the variety or strain. This condition is to be deplored since a relatively small amount of work on the part of the seed grower in properly roguing their seed fields would tend greatly toward the elimination of offtype or non-typical plants.

Long Standing

Spinach planted in February or March for spring cutting tends to run to seed quickly after the beginning of warm weather. For this reason it is desirable to have a strain possessing the necessary market qualities which will also be slow in developing seed stalks. Since there is apparently a negative correlation between long standing qualities of a spinach plant and its rapidity of growth, we are developing strains along two separate lines, one of which is for autumn and the other for spring planting. The long-standing spinach when planted in the autumn does not develop with sufficient rapidity to make it desirable for this purpose. In the

spring this difference is not as apparent. The long-standing strain of Manchuria stock was developed by crossing the Manchuria-Savoy hybrid with Long Standing. This has produced a very beautiful type of spinach.

Growth or Character of Foliation

This factor will usually be controlled by the selection made for other characters. The petioles should be erect and leaves reclined toward the tip which gives the plants much the shape of a deep, inverted saucer. The leaves should not rest on the ground as is the case with the Viroflay or Flanders type. This type of growth is particularly desirable for winter spinach since plants are not as likely to be affected by cold winds as are those of the Savoy which have a vase-form type of growth.

Summary

In breeding spinach for resistance to mosaic and improvement of type, consideration must be given to several factors. The resistance of the various strains was determined on a comparison of the percentage of plants affected with the disease with the percentage occurring in commercial strains. Size is determined largely by comparative measurements of the height and diameter of the mature plants. Savoying is measured by determining the increase which occurs in the leaf area due to this factor over that of a flat leaf of the same perimeter. Color is determined wholly by a system of scoring and comparison. Other factors, such as thickness of leaves, closeness, shape of the leaves, long-standing qualities, and the growth or character of foliage, are used in the determination of and improvement of type in spinach.

Effects of Cultivation on Soil Moisture and on Yields of Certain Vegetables

By H. C. Thompson, *Cornell University, Ithaca, N. Y.*

MANY experiments have been conducted to determine the effects of cultivation on yield of corn. Most of the investigators have concluded that practically the only benefit derived from cultivation by the corn plant is due to the destruction of weeds. There is some evidence that on very heavy soils cultivation has some additional value.

Cates and Cox[1] express the opinion that cultivation of corn has not been found beneficial from the standpoint of moisture con-

[1]Cates, J. S. and Cox, H .R. The Weed Factor in the Cultivation of Corn. U. S. Dept. of Agri. B. P. I. Bull. 257:7-35, 1912.

servation because the extensive root system of the corn plant takes up the moisture before it reaches the surface.

In the spring of 1919, G. K. Middleton, a graduate student, working under the direction of Prof. E. G. Montgomery, Cornell University, began experiments to test the value of cultivation of vegetables, for factors other than the destruction of weeds. During the season of 1920 the experiments were continued by the writer.

Outline of Experiments

In 1919, carrots, beets, onions, celery, lettuce, beans and tomatoes were used in the experiments. Results were secured on two crops of beets and carrots and on two methods of growing tomatoes. The plots were four rows wide and twenty feet long. One row in each plot was a buffer row which was discarded so that only three rows from each plot were harvested. The plots were duplicated In 1920 cabbage was added to the crops grown in 1919 and lettuce and beans were left out. In 1920, the plots were in triplicate and were five rows wide and twenty feet long (with the exception of the tomato rows which were thirty feet long). One row from each plot was discarded as in 1919.

The experiments were carried on in the vegetable gardens at Ithaca, New York, on Dunkirk gravelly sandy loam soil. The treatments given in 1919 were as follows: (1) Soil scraped to keep down weed growth; (2) Soil cultivated once and twice a week, and (3) Weeds allowed to grow. In 1920 the twice weekly cultivation was omitted, but the other treatments were the same as in 1919. On all the cultivated plots the cultivation was done with a Planet Junior cultivator. On the scraped plots the weeds were kept down by cutting them off at the surface of the soil with a sharp hoe.

Carrots, beets and onions were planted in rows 18 inches apart in both 1919 and 1920 and during both of these years the onions were started from seed sown in the greenhouse and the young plants set out four inches apart in the row. Celery was set six inches apart in rows three feet apart. Cabbage plants were set 18 inches by 3 feet. The tomato plants were set 2 by 3 feet when pruned and 4 by 4 feet when unpruned. The pruned plants were pruned about once a week, all of the lateral shoots being removed, and the single stem tied to a stake.

Yields of Vegetable Crops Under Different Treatments 1919 and 1920.

Since the treatments were not exactly alike during the two years the results are given separately. Table 1 gives the average yield per plat for the crops grown in the experiment in 1919.

TABLE I

The Average Yield of Vegetables Grown Under Different Treatments, 1919

Treatment	Average Weight of Harvested Crop in Pounds Per Plat										
	Carrots		Beets		Onions		Lettuce Early	Celery Late	Beans Late	Tomatoes	
	Early	Late	Early	Late	Early	Late				Pruned	Unpruned
Weeds allowed to grow ..	3.50	17.17	3.12	22.27	8.32	5.07	10 32	....	32.8	33.5	....
Weeds scraped	22.35	21.97	27.68	37.54	14.08	20.65	16.50	124.4	31.9	133.9	169.5
Cultivated (weekly)	20.75	19.87	....	....	14.69	32.42	21.44	....	....	....	....
Cultivated twice weekly .	22.72	20.92	33.18	34.82	14.21	33.23	22 46	135.2	33.66	163.9	178.4

Examination of Table 1 shows considerable difference between yields of early and late carrots and beets on weed plots. This was undoubtedly due to the fact that there was a heavy growth of weeds on weed plots during the growth of the early crops and a very sparse growth during the time the late crops were growing. On the results for 1919 Middleton makes the following statement:

"Because of large differences in certain cases between the yields from duplicate plots, the data cannot be taken as an absolute measure of the value of cultivation for these crops in this season. From a study of the yields and from close observations through the season the following conclusions seem justified: Early and late crops of carrots, a late crop of beets, and a late crop of beans showed very little advantage in cultivation over scraping off the weeds. The late onions, a crop of lettuce, and the tomatoes responded to cultivation more than simply to killing the weeds. There is a slight evidence that celery was also benefited by cultivation. With the early crop of beets and onions there was a very high experimental error, making it impossible to correctly interpret the results."

Table II gives the yields of the crops grown under the different treatments in 1920.

TABLE II

Average Yield of Various Vegetable Crops Grown Under Different Treatments in 1920.

Treatment	Average Weight of Harvested Crop in Pounds Per Plot						
	Carrots	Beets	Onions	Celery	Cabbage	Tomatoes	
						Pruned	Unpruned
Weeds allowed to grow	.....	.....	.....	......	98.46	88.80	88.85
Cultivated	39.91	54.00	79.66	151.83	124.45	143.96	106.54
Weeds scraped	39.08	49.50	66.75	115.66	143.17	141.40	101.94

The weeds grew so luxuriantly on the weed plots of carrots, beets, onions and celery that these crops grew very little. On the cabbage plots the weeds did not grow very large due to the fact that the ground was kept fairly clean until the cabbage plants were set out in July and after that the weed growth was limited on all parts of the garden.

The results given in Table II show no benefits from cultivation for carrots and cabbage. In fact the yield of cabbage was greater on the scraped plots than on the cultivated plots. Onions, beets, and celery responded to cultivation, and tomatoes show some benefits from cultivation on both the trained and untrained plots. It should be noted, however, that the stand of tomato plants was not perfect although the cultivated and scraped plots were about equal.

The results given are based on a full stand. Cultivation and scraping were discontinued on the untrained plots when the vines covered the ground.

The Effect of Cultivation on the Soil Moisture Supply

Soil moisture determinations were made only during the season of 1919 and on these Middleton reports as follows:

"Soil moisture determinations were made at 10 to 14 days intervals through the season from plots grown to onions (late crop), carrots (early crop), and from scraped and cultivated fallow plots. The samples were taken to depths of 6, 18, and 30 inches from plots receiving weekly and twice weekly cultivations and from the scraped plots. Composite samples were made from three borings at each depth. The drying was done in an electric oven at 105 and 110 degrees C., and the data were reported as an average for the surface 30 inches, in percentage, on the dry soil basis.

"Soil samples from the fallow plots were first taken June 5, while in the cropped plots the determinations began May 14. Because of an early spring drought, and also because of a crop of small weeds, these plots were already so dry (8.3 per cent) that there was no marked difference between the percentage in the scraped and cultivated plots during the remainder of the season, the average for the season showing 0.46 per cent in favor of cultivation. The data are not comparable to that from the cropped plots in which cultivation began earlier.

"The dates of taking moisture samples from the carrot and onion plots were the same to July 28, the carrots being harvested before the next determination."

The results of the moisture determinations are given in Table III:

Table III

The Average Percentage of Moisture in Scraped, Cultivated Weekly and Cultivated Twice Weekly Plots of Carrots and Onions, 1919.

Treatment	Onions		Carrots	
	Soil Moisture	Average	Soil Moisture	Average
Scraped	12.65	12.65	14.52	14.52
Cultivated (weekly)	13.66	13.90	13.84	14.33
Cultivated (twice weekly)	14.15		14.83	
Difference in favor of cultivation	....	1.25	....	-.19

Examination of Table III shows that there was very little difference in the moisture content of the soil from scraped and cultivated plots of carrots, but there was 1.25 per cent more moisture in the cultivated than in the scraped plots of onions. The conservation of moisture by cultivation of onions was probably higher

than the figures indicate as the plants in the cultivated plots must have used more water than did those in the scraped plots since the yield was 54 per cent greater in the former.

STUDIES OF ROOT SYSTEM

Studies of the root systems of some of the vegetables grown in these experiments give some explanation of the differences in their response to cultivation. The roots were exposed by washing the soil away by means of a fine hard spray from an adjustable nozzle. Middleton in 1919 soaked the soil before starting to wash out the roots. This was done by sinking a bottomless box two inches into the soil, waterproofing the sides and edges with clay, and keeping water in the box for one to two days. In 1920 the soil was not soaked in advance of the washing because it was found unnecessary. Before beginning the washing the soil was cut down across two rows within two or three inches of the plants, then the surface was studded with short stiff wires to hold the roots in place. The lateral roots near the surface were exposed by washing off the soil to the depth of several inches. The roots which grew downward into the soil were exposed by directing a stream of water against the vertical wall of a trench cut down within a few inches of the plants.

Very few onion roots reached a depth of more than 10 inches, though one or two were found as deep as 20 inches. The greatest lateral extent was 12 inches, but very few reached out more than six inches and the main root zone was found within a radius of six inches. A space of 6 to 12 inches wide in the center between the rows contained very few roots.

Carrot roots were found to fill the soil much more completely than the root of onions. The tap root and several other large roots arising from the side of the carrot were found to have reached the depth of 30 inches. These roots produced almost countless numbers of branches which were subdivided at least twice more. Directly beneath the plant the soil was well filled with roots to the depth of 25 to 30 inches. A space of 4 to 6 inches in the center between the rows was not so completely filled although at a depth of 4 to 8 inches many roots met and crossed in the center.

A large part of the roots of celery was found in the surface soil to a depth of six inches and within a radius of six inches of the plant. There was a distinct line between the surface soil and the subsoil, most of the roots stopping at the subsoil, although a few extended down 24 to 27 inches. The soil to a depth of six inches and within a radius of six inches was well filled with fine roots, but a space of 12 inches between the rows contained practically no roots. A considerable portion of the root system was found within two or three inches of the surface although the soil was quite dry during a large part of the season. There was no tap root, but from 30 to 50 main lateral roots grew out from the plant in all directions and these were covered with fine roots throughout their length. These fine roots were not subdivided.

Hundreds of small, fibrous roots 6 to 12 inches long grew out from the base of the plant, but these were not branched.

Cabbage roots were found to a depth of 30 inches, even the finer roots being found in considerable numbers as deep as 24 inches. However, a large part of the root system was found in the surface 12 inches which corresponded to the depth of the surface soil. The roots extended laterally as far as three feet and were about as plentiful midway between the rows as within a few inches of the plant. The roots were branched many times so that the soil was quite thoroughly filled to the depth of six inches, although the greatest mass was found within three inches of the surface. Most of the cabbage roots are quite small, but of about the same size throughout their length.

Conclusions

While the results are not entirely consistent it seems perfectly evident that some vegetable crops respond more to cultivation than do others. From a study of the root systems it appears that those crops which respond least to cultivation, over scraping to keep down weeds, are the ones having the greatest growth of roots. Where there was considerable space between the rows which contained few or no roots cultivation increased the yield. On the other hand, where the space between the rows was well filled with roots cultivation did not increase the yield over scraping. In fact with cabbage, which crop had the largest root system, the cultivated plots produced much less than the scraped plots. Some of the roots near the surface were probably broken by cultivation. Celery and onions responded to cultivation more than the other crops and these two had the poorest distribution of roots and the most space between the rows without roots. There is apparently a correlation between the root system (extent and distribution) and the response of the crop to cultivation, for purposes other than the destruction of weeds.

Control of Downy Mildew of Lettuce

By A. T. Erwin, *Iowa State College, Ames, Iowa.*

LETTUCE is the most important vegetable crop grown under glass in Iowa. In some seasons a disease known as downy mildew is one of the most serious troubles met with in forcing this crop. Competition with garden lettuce from the Pacific Coast and the Gulf States together with the high cost of production, makes the control of downy mildew an urgent question with many Iowa growers. The affected plants in time show the typical white downy mildew on the under surface of the leaves, the foliage takes on a yellowish cast of green and the plant becomes seriously stunted in growth. With the arrest of growth the tissues lose their

succulent quality and the plant becomes worthless for salad purposes.

The downy mildew of lettuce has long been known a destructive garden and greenhouse disease. It is caused by a parasitic fungus, *Bremia lactucae*, which is widely distributed in both Europe and America.

The first report of the occurrence of lettuce mildew in America, at least as to its being of economic importance, seems to be that of Farlow* in 1875. At that time he recorded it as becoming serious in the vicinity of Boston, which was the first commercial center for lettuce forcing developed in the United States.

The importance of this disease in this state was first brought to the attention of the writer in 1914 by Blackman Brothers, lettuce growers, at Nevada, Iowa, who reported that their winter crop had become so seriously stunted in growth that it was unprofitable.

Susceptibility of Different Types to Downy Mildew

Herewith is presented a study of measures for its control made by the writer, and also certain phases of its life history which bear directly upon this problem.

Twenty-seven varieties of lettuce representative of the loose leaf, the cos and the head lettuce types were inoculated by the usual spore suspension method in the seedling stage. The plants were then placed in a moist chamber for 24 hours thus subjecting them to conditions favorable to the growth of the fungus. Following this they were removed to open benches in the greenhouse. They were inoculated on March 9th and inspected one week later. All of the varieties in all the groups were infected ranging from heavy to very heavy.

Age of Plants As Related To Infection

The question as to whether the plant is more susceptible to infection at one period of development than at another was also investigated. A test was made with eighteen varieties including representatives of the three classes or types, loose leaf, cos and head lettuce, in which the plants were inoculated with the mildew at the respective ages of 21, 31, and 45 days, from the planting of the seed.

This experiment was made in a greenhouse which being airy and well lighted does not offer conditions most favorable for the mildew. In order to provide conditions more favorable for the development of the disease, the beds on which the plants were grown were converted into moist chambers by raising the sides 12 inches with boards and covering the tops with hotbed sash. Into these beds were transplanted the lot 3 plants, and to it were transferred the pots containing lots 1 and 2 immediately after the seedlings which they contained had been inoculated.

The seed was all sown in 12 inch pots, three pots for each va-

*Bulletin-Bussey Institution. Page 427, 1879.

riety under test. Shortly after germination the seedlings were thinned to 100 to the pot. The plants for lots 1 and 2 were allowed to remain in the pots. The lot 3 plants were transplanted to a bed which had been converted into a moist chamber as above described, but they were not inoculated until after they had fully recovered normal condition of growth activities after being transplanted.

Lot 1 was inoculated at 21 days, lot 2 at 31 days and lot 3 at 45 days from planting.

Six days after the respective inoculations the plants were examined for mildew. Lot 1 had 90 per cent of the plants attacked, lot 2 had 38 per cent, and lot 3 had 19 per cent. These results emphasize the fact that downy mildew of lettuce is primarily a seedling disease.

A study of the above figures indicate clearly that the downy mildew of lettuce is distinctly a disease of the young seedling. The critical period for infection is when the plants are small, particularly at the age between the unfolding of the cotyledons and the expanding of the first true leaf. If the plants can be kept free from the mildew until they are half grown, the disease is of comparatively little importance.

On the other hand in case the mildew gains a foot hold on the young seedling, the stunting effect on the young plant becomes very apparent by the time the plant is half grown. Such plants make only a slow growth and never fully recover.

Wild Lettuce Breeds Mildew

Wild lettuce is a coarse weed which is often found abundantly in neglected corners about the compost yard. In considering control measures, the question arose whether wild lettuce is affected with downy mildew, and if so whether it is the same species that grows on cultivated lettuce. If it is, its eradication obviously would be the first step in preventing the disease.

For the purpose of securing information upon this phase of the subject, wild lettuce plants were inoculated with spores of mildew taken from cultivated lettuce, and conversely, cultivated plants were inoculated with spores of the mildew from wild lettuce.

On October 6, 1916, mildew was found upon the cultivated lettuce in a cold frame at the College greenhouse. A few days later mildew was also discovered in abundance upon young seedlings of wild lettuce. Spores taken from this material were used for the inoculation experiments above mentioned.

Wild Lettuce Inoculated With Mildew From Cultivated Lettuce

For the purpose of furnishing material for the inoculation tests, a quantity of plants of different species of wild lettuce were grown under control conditions in the greenhouse from seed gathered from wild plants. When the seedlings were one inch high

they were inoculated with mildew from cultivated lettuce by the spore suspension method. The following is a tabulation of the results:

Species of lactuca	Date of planting	Date of inoculation	Date of examination	Results
	LOT NO. I			
Lactuca scariola var. integrata	October 7	October 24	October 30	Positive
Lactuca canadensis	October 7	October 24	October 30	Positive
Lactuca sagittifolia	October 7	October 24	October 30	Positive
Lactuca ludoviciana	October 7	October 24	October 30	Positive
Grand Rapids (Check)	October 7	October 24	October 30	Positive
	LOT NO. II			
Lactuca scariola var. integrata	October 7	November 3	Nov'mb'r 11	Positive
Lactuca canadensis	October 7	November 3	Nov'mb'r 11	Positive
Lactuca sagittifolia	October 7	November 3	Nov'mb'r 11	Positive
Lactuca ludovicana	October 7	November 3	Nov'mb'r 11	Positive
Grand Rapids (Check)	October 7	November 3	Nov'mb'r 11	Positive

Cultivated Lettuce Inoculated With Mildew From Wild Lettuce

The plants of cultivated lettuce which were used in the inoculation experiments, were grown in the greenhouse under control conditions. There were two stages of growth, namely, small plants with the first true leaf developed, and larger plants which were about half grown.

The small plants were held in a moist chamber described previously. The larger plants were benched and protected by a muslin cage from spores which might be floating in the air. The results are set forth in the following table:

Variety of Lactuca	Number of plants	Date of planting	Date of inoculation	Date of examination	Diseased	Not diseased
Grand Rapids	(a) 30	Oct. 20	Nov. 3	Nov. 11	30	0
Scariola var. integrata (check)	10	Oct. 20	Nov. 3	Nov. 11	0	10
Grand Rapids	(b) 20	Oct. 20	Nov. 4	Nov. 12	20	0
Scariola var. integrata (check)	20	Oct. 20	Nov. 4	Nov. 12	15	5
	Large Plants					
Grand Rapids	(c) 20	Sept. 25	Nov. 8	Nov. 14	7	18

The study of the tables shows clearly that mildew of wild lettuce grows readily on cultivated lettuce, and, conversely, the mildew of cultivated lettuce is readily propagated on wild lettuce.

Here was an important discovery. It becomes evident that wild lettuce plants growing in the vicinity of greenhouses or frames where lettuce is being forced, are a breeding ground for mildew which may seriously injure or destroy the value of the crop. The first step in preventing lettuce mildew is, therefore, to completely destroy all wild lettuce plants in the vicinity.

Control Measures

The control of the disease was undertaken from three angles, soil disinfectants, fumigation and spraying.

The "Drench Method"

The soil was watered with a formaldehyde solution using seven pints of formaldehyde to one hundred gallons of water, and applied at the rate of one gallon to each square foot of surface as has been recommended.*

*Shelby & Humbert, Ohio Agri. Expt. Sta., Cir. No. 151, 1915.

Experimental Data

On February 16, 1917, eighteen twelve-inch pots were filled with soil which had recently grown diseased lettuce.

Lot 1, consisting of nine of the pots, was saturated with formaldehyde solution, one to thirty.

Lot 2, consisting of the remaining nine, was left untreated as a check plot.

Both lots were sown to Grand Rapids and lot 2 placed in a separate compartment. The seed of both lots germinated promptly, and there was no evidence of impaired germination from the formaldehyde. The seedlings were then thinned to one hundred to each pot, or a total of nine hundred in each lot, to secure uniformity.

As soon as the cotyledons had fully developed the plants were observed closely for symptoms of the disease. The results were as follows:

Formaldehyde As a Soil Disinfectant For The Control of Downy Mildew of Lettuce

Variety—Grand Rapids.
Date sown—March 15.
Period under observation—March 28 to April 2.

Lot No.	Per Cent Infected.
1	100
2	98

In the fall of 1914, the lettuce house of Blackman Brothers, Nevada, Iowa, was treated with formaldehyde solution one to thirty. The beds are solid and it was aimed to saturate the soil spade depth, using one gallon to each square foot.

This house is used entirely for maturing the plants, the seed-

lings being handled up to the transplanting state in an adjacent house. The treated soil was set to lettuce early in September. By the middle of November the plants showed serious infection from downy mildew and before reaching maturity the entire crop became thoroughly infected.

In both of these instances formaldehyde failed as a control measure. There can be no doubt as to the soil being disinfected in the first instance, as the soil was supersaturated.

In any case soil infection is only half the problem. Aerial infection must also be guarded against.

Soil treatment alone will not succeed and is really one of the most difficult and expensive methods of control. Given a healthy soil to start with, spraying, general sanitation and the proper cultural relations, are the more feasible methods of control.

Bordeaux Applications

Investigations were made as to the relative value of different strengths of bordeaux mixture for control of mildew on lettuce seedlings. For this purpose Grand Rapids seedlings were started in pots. Just before the true leaves appeared the different lots were treated with bordeaux as set forth in the following table. Two days after this treatment all of the plants were sprayed with water in which an abundance of fresh mildew spores were in suspension. Examination after six days showed the results tabulated below.

Susceptibility of Lettuce Seedlings to Downy Mildew When Sprayed With Different Strengths of Bordeaux

Variety—Grand Rapids. Date Sown, January 14th. Date Sprayed with Bordeaux, February 2d. Date Inoculated, February 4th. Date Examined, February 11th.

Strength of mixture	Plants per pot	Leaves and cot.	Leaves only	Cot. only	Both cot. sur.	Upper cot. sur.	Lower cot. sur.	Plants diseased	Plants not diseased	Diseased plants per cent
Check ..	106	0	0	98	95	0	3	98	8	92.4
2-2-50 ..	138	0	0	10	2	0	8	10	128	7.3
4-4-50 ..	92	0	0	8	6	0	2	8	86	8.2
6-6-50 ..	120	0	0	20	14	0	6	20	100	8.5
8-8-50 ..	118	0	0	22	4	0	18	22	98	8.6

This experiment indicates that lettuce mildew may be readily controlled by bordeaux mixture at a 2-2-50 strength, and that nothing is gained by using a solution stronger than 4-4-50, which is the general formula for other garden crops. It may also be noted that bordeaux mixture of this strength does not injure lettuce foliage.

Spraying Experiments With Bordeaux Mixture

An experiment in the treatment of young seedlings was conducted to test the value of one treatment of bordeaux mixture as compared with two treatments. The varieties used in this test were Belmont, Tennisball and Big Boston, which were growing in a cold frame. The bordeaux mixture was used at the strength of 4-4-50.

On March 12, when the first true leaves were just appearing, two flats of each of the varieties named were thoroughly sprayed with bordeaux mixture. A week later one flat of each variety was given a second treatment.

When the seedlings had reached the proper stage for transplanting, those which had been sprayed once showed 5 per cent infected with mildew, while those which received two treatments showed less than 1 per cent.

In an experiment to test the value of bordeaux mixture after the plants were half grown, Grand Rapids plants were used. These were started in the usual way and transplanted to flats at the proper time and grown in a cold frame. There were forty flats, making 4,000 plants used in the test. Diseased plants were introduced and this lot became badly mildewed. Three flats were then removed to a corresponding frame where they were held as a check. The plants in the other 37 flats were then thoroughly sprayed with bordeaux mixture.

An inspection made one week following this treatment showed 35 per cent of the treated plants and 72 per cent of these untreated infected with the mildew. A very important feature of the results is not indicated in these figures. The sprayed plants, which before treatment were showing a good deal of the unhealthy color characteristic of mildewed lettuce, had regained normal color and grown to a considerable degree. Eventually these developed solid heads. The unsprayed plants, on the other hand, developed very slowly and for the most part were lacking in succulence and quality.

Fumigation with sulphur has been repeatedly recommended in popular garden literature for the control of various kinds of downy mildew. In the control of rose mildew, sulphur is commonly applied either direct, or with lime to green house pipes. Experiments were conducted to determine the efficiency of fumigation with sulphur in this way for the control of lettuce mildew, and also to determine the amount of time the lettuce may be subjected to sulphur fumes without injury.

Sulphur fumes were generated by vaporizing sulphur on a sand bath heated by a small kerosene stove, using ½ gram of sulphur per cubic foot of space. The heat was regulated so as to vaporize the sulphur but not to ignite it. Various lots of seedling plants were placed in a wardian case and exposed to sulphur fumes for different periods of time. Spores taken from the treated plant were then tested in the usual way for germination. This experiment was repeated 3 times. The following table shows the length of treatments and the average germination of spores of the three tests.

Time exposed, minutes	Per cent of germination of spores after treatment	Effect on plant
15	13	No injury
20	4	Slight injury
30	3	Severe burning
40	0	Severe burning
60	0	Very severe burning

Since in these tests it requires over 30 minutes to kill all the spores, and exposure beyond 15 minutes resulted in injury to the plants which varied from slight to more and more severe as the length of exposure was increased, and since the condition of these tests no doubt represents fairly well the average conditions under which the work would need to be done, it appears that the problem of controlling lettuce mildew by fumigating with sulphur is not an easy one. From the standpoint of the commercial grower, it is evident that less risk and more reliable methods, are needed. A single illustration taken from experience of a commercial grower proves this point.

On the night of March 11, 1916, Blackman Brothers of Nevada, Iowa, fumigated the lettuce house with sulphur using 12 ounces per 1,000 cubic feet. The mildew present on the surface was destroyed, every trace of it being removed. The plants were severely burned, about 30 per cent of them beyond recovery. The remainder were set back two weeks in their development.

As noted above, the serious problem in the use of sulphur for fumigation is not to kill the spores, but to avoid injuring the plants.

Summary

In some seasons downy mildew is a serious factor in forcing lettuce in Iowa.

Continued periods of cloudy weather which often prevail during the forcing season in this section, are highly conductive to the growth and development of the disease.

Wild lettuce plants afford a breeding ground for the disease, and should be destroyed in the vicinity of forcing houses.

Bremia lactucae is primarily a seedling disease. Control measures, to be effective, must be focused upon the seedling stage of the plant.

Bordeaux mixture of the standard formula, 4-4-50, is recommended for its control. The first application should be made as soon as the plants are up, and a second, a day or two before they are "pricked off." In some instances, a third spraying before the plants go into the permanent beds, may prove advantageous.

Proper ventilation and a dry foliage in periods of dark, cloudy weather, are important in preventing the growth and spread of the disease. These operations must be co-ordinate with the control measures indicated above.

Teaching Systematic Olericulture

By J. R. HEPLER, *Agricultural College, Durham, N. H.*

ONE of the most interesting courses offered by the horticultural departments is the course in systematic pomology. It is usually a required course for horticultural students and very often elected by students not specializing in horticulture. Why has the systematic study of vegetables not made the same progress? (1) Probably because of the greater popularity of the apple as a subject of discussion in the trade papers and meetings of horticulturists. (2) The lack of courses and often of competent instructors in systematic olericulture. (3) The lack of constant standards in the description of vegetable varieties. (4) The continual changing and renaming of varieties.

A course in systematic olericulture should include a botanical study of the plant families used for vegetables, a description of the standard varieties and types of vegetables, and the identification and judging of the more common ones.

The value of such a course is unquestioned. In the first place, it teaches taxonomic botany in its most practical phases. The classification of higher plants is not a required course in most of our colleges at the present time and a good many of our horticultural students are graduated with very little or not any work in plant classification. The number of plants cultivated and used as vegetables includes at least 37 families and over 250 species. While not all of these are available for examination the list which can be had is very large.

It also teaches the description and identification of the principal types and varieties of vegetables. This is perhaps the most difficult part of the course to teach because of the lack of standard types in a good many of our vegetables. The type of a sexually propagated and highly bred annual or biennial like a tomato or cabbage often changes very quickly. We have different strains of the Earliana tomato or Wakefield cabbage which vary greatly in size, shape, productiveness, and other factors from the original or even the most widely grown type.

We have, however, made considerable progress along the lines of standardization with a number of vegetables. There are perhaps 500 varieties of potatoes, or at least that many varietal names. Stuart has been able to classify them into 15 groups, while Milward of Wisconsin clasifies the commercial types into 8 groups, four early and four late ones. The work of the certified seed inspectors and the county agents has helped to standardize commercial types so that the number of varietal names is decreasing. The work of Jarvis on beans, and that of Tracy on beans and lettuce, have done a great deal toward giving us an authoritative description of varietal standards with these two vegetables.

We are less fortunate with the root crops, for here we have to

rely chiefly on seed catalog illustrations for a description of what the type should be. Most of the strains of carrot, beet, radish, and parsnip seed have been so badly mixed during the last four years that the beginner is puzzled as to what the proper type should be.

Identification is largely a matter of learning the variety or type names and associating them with the typal characteristics. Constant practice with typical specimens is necessary to fix these in a student's mind.

From the commercial standpoint, a study of the variations caused by soil or climatic conditions is perhaps the most important feature of the course, especially a study of those variations relating to texture and quality. A laboratory examination of Rural New Yorker potatoes, including a cooking test, will show that this variety is of high quality and quite mealy when grown on sand, but very soggy and of poor shape and quality when grown on heavy soil. A well grown New England potato is of much higher quality than one grown 200 or 250 miles further south. The same iis true of practically all the cool season crops and the short season tender crops, while the opposite is true of the warm season crops.

The most satisfactory method of teaching the course, in my opinion, is to divide the work into three parts. First, is the lecture work which is given wholly by the instructor; second, the outside assignments which should be prepared entirely by the student with very little help; and third, the laboratory work which is done by the student under the direct supervision of the instructor.

The lectures should consist of a history and description of the botanical families and species of vegetables especially those not studied by the class, and a description of the varieties and types of each one. Special attention should be given to those characteristics upon which varietal distinctions are based. Thus in cabbage we have the two types characterized by plain and savoyed foliage, with a further color classification in the former class, and the additional varietal distinctions made up of such factors as shape of head, size of head, time of maturity, length and thickness of stem, internal structure, etc. In rutabagas, on the other hand, the classification is far more simple, consisting merely of a difference in color of flesh. A general description should also be given of those vegetables which are not in common use, giving the habits of the plant and its use as food.

The outside assignments should consist in the study of the botany of certain families of vegetables including all their botanical and horticultural varieties. One or more families are assigned to each student. The chief references used in this part of the work are Bailey's Encylopedia, Vilmorin's Vegetable Gardening, the United States Department of Agriculture bulletins on potatoes, lettuce, and beans, the Cornell bulletins on beans, and also various other bulletins together with textbooks, tradepapers, and seed catalogs. The student also uses his laboratory reports for the variety characteristics. The following outline is an illustration of the student's finished work:

Family..Solonaceae,

Species—Lycopersicum esculentum

Bot. Var. (var) Vulgare, common tomato

$$\text{Color types}\begin{cases}\text{red..Maturity}\begin{cases}\text{early..Earliana}\\ \text{midseason}\\ \text{late}\end{cases}\\ \text{pink}\\ \text{yellow}\end{cases}$$

A short characterization of the variety should follow the variety name.

The laboratory work should consist of the description of different varieties and practice in identification and judging. In the description of varieties one blank form for each vegetable is given to each student as an outline to follow. The student writes out all his descriptions in his notebook which is handed in for examination. The outline is patterned after the forms used in the variety tests in the United States Department of Agriculture, but is not nearly so comprehensive as a multiplicity of minor variations and slight differences simply confuses the student without adding to the characterization of the variety. It calls attention only to the most important of the variations which constitute variety or type in a species. An effort is made to have the outline apply to the vegetable as the student sees it, and no mention is made of seasonal notes which must be made during the growing period.

As much as possible of the laboratory work is done in the garden although in our northern states, early fall frosts often kill certain vegetables such as tomatoes and the vine crops before the class gets a chance to study them. Crops like peas and string beans may be preserved in formalin, or a combination of formalin and copper sulphate, but preserved vegetables are not very satisfactory to work with.

A sample outline follows:

Tomato

Botanical name..

Common name..

Type ..

- Plant
    - Size
    - Vigor
- Leaves
    - Number
    - Outline
    - Size
    - Color
- Fruit clusters
    - Number of clusters
    - Number of fruits in clusters

Fruit
- Size
- Color
- Shape (draw cross sections)
- Size and shape of cavity
- Blossom end

Flesh
- Color
- Thickness
- Flavor and quality
- Walls, size
- Cells
  - Number
  - Arrangement
  - Well filled with pulp

Variety resembles .... type
Distinct..
Use and special adaptation
Notes

Terminology of Orchard Soil Management Methods

By R. J. Barnett, *Agricultural College, Manhattan Kansas*

ONE of the primary prerequisites for clear speaking or writing and, in a measure, clear thinking regarding any subject is that the words used shall have definite and generally accepted meanings. Horticulture suffers in many ways because of being in a state of uncertainty or transition respecting the scope of meaning and limits of application of many words descriptive of both objects and processes connected with it, and this not only as an art, but also a science. In few other subdivisions is this uncertainty more marked and more likely to lead to loose thinking, inaccurate statement, and general confusion than in the case of methods of orchard soil culture, using the word culture in its correct meaning rather than as synonymous with cultivation.

Only a brief survey of pomological literature is needed to compile a considerable list of terms applied to the various systems of orchard soil culture and to discover from the context that a single process may be known under several different names, and that the same word may have more than one meaning, may be applied to two or more different methods of culture. Thus the more careless writers fail to distinguish between the terms intercrop and cover crop; between sod and sod mulch systems; between the employment of grasses and of legumes in the orchard; do not know, apparently, that shade crops are anywhere used, or that thousands of acres of producing orchard land are permanently seeded to

alfalfa; have no definite term for that system in which organic material is hauled onto the orchard land to decay; and are in general ignorant or careless regarding the distinctions which exist between any two of these methods of culture. Such confusion prevents a clear understanding of the printed page and is peculiarly harmful in its effect on young students of pomology.

The orthography of the vocabulary relative to this subject is also somewhat uncertain, especially with respect to the use of the hyphen in the compounding of descriptive terms.

By way of opening the discussion of this subject, but without any particular desire to influence any action which the Society might wish to take, the following list of terms descriptive of various orchard soils management methods with their orthography and definitions is submitted:

1. Sod culture. Under this system the orchard land is seeded down to grass, or grass and clover, and the annual growth is either pastured down or taken off the land in the form of hay. A true sod is formed.

2. Intercrop. Under this system some crop other than grass is grown between the tree rows, harvested, and removed from the land.

3. Clean cultivation. Under this system of orchard soil management tillage is commenced early in the spring and continued throughout the growing season.

4. Mulch culture. Under this system a mulch of vegetable material sufficient to prevent all weed growth is placed on the orchard land and allowed to decay there.

5. Cover crop. Under this system the orchard land is seeded to some perennial crop, none of the annual growth of which is removed from the orchard. The top growth may or may not be clipped.

6. Half cover crop. Under this system strips of perennial plants are grown between the tree rows while the soil in and close to the tree rows is clean cultivated.

7. Annual cover crop. Under this system the orchard land is clean cultivated throughout the greater part of the growing season and is planted to and occupied by an annual, or a biennial grown as an annual, cover crop during the remainder of the year.

8. Shade-crop. Under this system the orchard land is seeded to some crop during the early summer and cultivation suspended until late fall or the following spring. It is applicable to irrigated lands and regions of high summer insolation and heat.

9. Artificial fertilization. This system contemplates the combination of any of the other methods of culture with the application of either barnyard manure or commercial fertilizers. The use of such fertilizers would not of itself constitute a separate method.

A few words of explanation regarding some of these lexicological suggestions may serve to make the case somewhat clearer. The technical definition of an orchard cover crop might be, that system

of soil management under which any crop is grown on and turned back into the soil for the sole benefit of the trees. The acceptance of this definition leaves no place for the term "sod mulch" which has been more or less current in the pomological literature of the last decade. In many sections, too, the most commonly grown crops for this purpose are the clovers and alfalfa, which certainly do not make sods as do the grasses.

Shade-crop is hyphenated following the usage of Paddock and Whipple who were, so far as the writer knows, the inventors of this term. "Intercrop" will include fillers, though their use might be construed as a different system. The distinction between sod culture and intercrop is more convenient than logical.

If this Society were to invite discussion of matters of this kind, take formal action regarding them, either after or without reference to a committee, and publish and recommend their findings the sanction thus gained should result in fixing usage and thus enable American horticulture to advance one step as a science.

Has the Orchard Survey a Place on the Research Program?

By R. D. ANTHONY, *Pennsylvania State College, State College, Pa.*

ONE of the problems which has assumed serious proportions in our colleges and experiment stations in the last four or five years is how to reduce to a minimum the loss caused by changes in staff personnel. It has been more serious in the experiment station than in the college because of the value to the research man of a knowledge of local conditions. From the worker's standpoint, each of us has felt the handicap imposed when we tried to take up the work of another, even though ours might be a very subordinate position.

Boards of trustees, by their attitude toward research, can remove some of the causes which have led to so many changes, but it is inevitable that there should be a very considerable shift from college to college and from college to commercial work. So long as these changes can be made to bring new life and vigor to our work they are desirable, but the research work of the department must be so planned that the loss of men can, at the most, only slow up, not disrupt it.

This is not an easy task. It demands the organization of the work into a few, well defined lines of endeavor around which the subordinate projects of the department are grouped. As long as these lines of effort are selected because of the interest or hobbies of a certain man or group of men, the continuity of the work is endangered. When we can ground our research plans upon the urgent need of the horticulture of the state, once the work is well

under way, its life becomes, to a large extent, independent of the changes in personnel of the department.

Two years ago the pomological research at the Pennsylvania Station was placed in the Department of Horticulture and its conduct turned over to a new man. At the same time, several of the old experiments were dropped and new land secured. Because of these changes it seemed desirable to remodel the entire research program.

We all believed that the permanency of this work depended largely upon the success with which it was coordinated with the pomological needs of the state. But what were the needs of the state? Was our knowledge of conditions in the state sufficiently broad to enable us to answer this question? Should we go ahead with our present knowledge, or should we hold up our plans for a year or more and spend several thousand dollars trying to increase our knowledge?

To those of you who have lived in states where the fruit interests lie in a single, definite region, with fairly uniform climatic and economic environment, such questions may seem to indicate that what was needed, instead of a survey, was a housecleaning and a new crew that really knew their business; but a glance at the map of Pennsylvania and a few words of explanation may show some of our difficulties. Pennsylvania has a greater area than the New England States, outside of Maine, with New Jersey and Delaware thrown in, and her climatic range is fully as great as that experienced in these seven states. In fourteen hours on a through train one goes from the peach orchards of Delaware County, past the blue berries and riparias of the mountains, to the vineyards of Lake Erie.

A few words as to location of our fruit districts may be of interest to those who are not familiar with the state. We must recognize at least five fruit districts in the state, each usually very distinct from all the others in climate, soils, varieties, cultural methods and marketing. In the vicinity of Philadelphia and including Delaware, Chester and Montgomery Counties and part of Bucks and Berks Counties, is a region splendidly adapted to apple growing and also well suited to the peach. Here the orchards are young, usually well cared for and of such varieties as Stayman Winesap, Jonathan, Grimes and Delicious. The method of selling direct to the consumer is just becoming well established.

North of here in the vicinity of Scranton and Wilkes-Barre and including Luzerne and Lackawanna Counties and parts of Wyoming and Wayne, is another region which reminds one of Western New York in its varieties, the size and age of many of its trees, and in the plan of growing fruit as one of several crops on the farm. Though there are some orchards of over one hundred acres, the five- to ten-acre orchard is the most typical. The orchards are largely in sod and here three-fourths of the apples reach the consumer either direct from the orchard or through but one extra pair of hands, the grocer's.

The most famous region lies in the Cumberland Valley, the

northern continuation of the well known Shenandoah Valley, and in the territory adjoining this. The Counties of Adams, Franklin, York, Cumberland and Bedford, are in this group and comprise our car-lot shipping region. Stayman Winesap, York Imperial, Jonathan, Ben Davis, and Grimes, are commonly grown. The orchards are young, are usually cultivated and are given good care. The orchard is the chief crop and usually the only crop on the farm.

The counties grouped around Pittsburgh form another and not so well defined region of both young and old orchards, peaches and apples, well and poorly cared for orchards, and northern and southern varieties. Almost universally the fruit is sold to the consumer either direct or through the grocer.

In the Erie district the grape so over-shadows all other fruits that at first glance one sees nothing but vineyards, yet cherries, prunes, peaches, apples and small fruit, are being used more and more to balance the vineyards. Most of the Erie fruit is sold to the canneries, juice factories, local buyers, or on commission.

Outside of these regions are many fine orchards feeding into such cities as Harrisburg, Lancaster, and Reading, or into some of the several hundred factory and mining towns, and scattered throughout the state are the remains of the one and two acre farm orchards set out in the sixties and seventies.

It was this complexity of our fruit conditions which made us anxious to study them in the field before we went further with our research plans. Our own department did not have funds for this, but fortunately the Secretary of Agriculture at Harrisburg recognized the possible value of such work to the people of the state and offered to finance an apple orchard survey if, instead of doing two counties as we had planned, we would take the entire state and finish it in one season. This looked like a big undertaking, but we finally accepted the conditions.

We planned the survey to supplement the Federal census report for the state and, as this would give us the total number of orchards and the acreage, we did not attempt to survey every orchard in each county we visited. What we wanted was a slice which was sufficiently representative so that whatever conclusions we drew from our study of this slice could be applied in the entire county.

On July 1st we called our survey men together for a preliminary school and on the 5th began our field work with ten men and five Ford cars. By September we had finished all the important regions, but two of us continued the work in the outlying areas until the first snow storm.

Before starting the survey we spent weeks writing and rewriting our survey blank and then used it in the field a week and again rewrote it, but in spite of this it did not prove satisfactory. The real trouble, however, was not in the blank, but in the nature of apple orcharding in most of Pennsylvania. All previous orchard surveys have been taken in the larger commercial regions and have covered a limited territory where climate and economic conditions

were nearly uniform. This was a state-wide survey covering a wide range of conditions and we soon found that our local market orchards presented problems from the survey standpoint. It was not an uncommon thing to find 25 varieties in a 5 acre orchard, and it was seldom that the local market grower could give us his yields by varieties, or even his total yield, with any degree of certainty, and the question of prices brought nearly as unsatisfactory answers. When a man harvests his apples through five months, goes to market from one to six times a week, takes a half dozen kinds of farm produce each time, and sells them in amounts varying from quarts to wagon loads, the task of keeping track of yields and income becomes too complicated for most growers. With close to half the fruit in Pennsylvania sold in this way, the difficulty in filling out a survey blank in terms of dollars and bushels becomes apparent.

Under these conditions we soon found that the most valuable product of the survey was the district reports we wrote every few days, reviewing the points covered by the survey blank and including the many things not in the blank. In these reports we also sought to give the points of similarity and of contrast of each new territory with those already covered. These reports, alone, we consider worth the time and money spent on the survey.

We had expected to send survey blanks in advance by mail to all the men we planned to visit, but we soon found these were seldom read over so we abandoned the plan. We found our best introduction was the publicity we could get through the local papers. The reporters and editors were much interested and only too glad to feature the survey and report its progress from day to day. Except in the immediate vicinity of Philadelphia and Pittsburgh, where the local papers were completely over-shadowed by the city daily, we found this free advertising saved us hours of explaining what our visit was for. Large signs on our cars also helped us.

At first we were a bit doubtful of the attitude the growers might take, but we soon found that our most serious problem was how to get away from each grower. Frequently when by much insisting and some strategy we had gotten back to our cars, the grower would jump in and go along to the next on our list to introduce us and incidentally to ask more questions on the way. Questionnaires may get a cold reception nowadays, but if the fruit grower thinks you have any information he can use he will meet you more than half way and tramp the legs off you showing you every tree on the farm.

Before starting in each new territory we prepared lists of growers from the membership of the state and county horticultural societies, but especially from the farm bureaus. Such a survey as this would lose much of its value if not carried on in close cooperation with the county agents. But our best source of information was seen to be some gray-beared apple man who had grown up in that region and who knew the fruit men and orchards for miles around. When we found such a man we sat down with him

under a tree in the orchard, spread out our maps, and soon had several days' work planned out.

For maps the best were the contour maps of the United States Geological survey, but these not being available for all the survey, we also had to use the Post Office and highway county maps, but neither of these was accurate or gave us elevations.

At night the field surveys were copied on permanent blanks printed on a different colored stock. This was tedious work, but it saved time in the field as we could abbreviate and use short-cuts and it also eliminated many errors.

We used Ford cars and found them satisfactory in so far as they brought us back to the hotel each night, but our repair bills were high and we found the fatigue of driving 100 to 125 miles a day over strange roads was excessive, and we concluded it would have been better economy to have had one or two easier driving cars for the long runs.

In spite of our many difficulties, we were able to secure surveys of over 20,000 acres of apple orchards, and we also visited several thousand acres which were not reported on the survey forms. Although this was strictly an apple orchard survey, we were able to pick up considerable valuable information for the other fruits.

Our method of organization proved satisfactory. We had two crews of five each and each crew took a separate region. One of the five was the leader and responsible for the multitude of details in running the crew. It was also the leader's business to get bird's-eye views of the territories studied and to check his impressions with those of the other men.

Did the survey pay us for all the time and effort and money expended? Although we are just beginning to realize on the investment, we feel that we are already more than repaid. We feel that our knowledge of fruit growing in Pennsylvania is much more substantial and that we are more intimately acquainted with the grower's problems. We have established contact with a splendid group of men whose advice and experience have made the survey worth while and will continue to be at our service. We feel that our chances of planning and conducting our research in such a way as to be of service in our turn are much brighter.

What, then, is the place of the orchard survey in the research program? In speaking of this survey we have called it a reconnoissance survey and I think this term rather clearly points out the functions of a field survey. It should be used as one of the means to keep college teaching and station research in close contact with actual field conditions. We have been justly criticised for our failure to do just this thing.

The Probable Value of Trunk Circumference as an Adjunct to Fruit Yield in Interpreting Apple Orchard Experiments

By J. H. WARING, *Pennsylvania State College, State College, Pa.*

IT is frankly admitted, with regret, by practically all pomological investigators, that the many projects in apple orchard soil fertilization, although conducted with care through many years, have not yet taught us their lessons with sufficient conclusiveness to form a basis for definite recommendations as to general orchard practice. If the results obtained do contain such lessons, we have been in large measure blind to them, and surely no more valuable contribution to the science could be made than to take what has thus far been largely a debit and transform it into a credit, a lamp to guide us to better work and toward more conclusive results in the future.

With this high hope inspiring us, we at the Pennsylvania State College have been working over the records of the well-known experiments that were begun by Dr. John P. Stewart, and which formed the basis of several bulletins of the Experiment Station. Results of fertilizer applications were kept in two terms; namely, in the number of inches gained in trunk circumference by each tree, and in the number of pounds of apples produced by each tree. The purpose of the present paper is to find out the probable value of the circumference records in conjunction with and correlated with the yield records in leading to the correct interpretation of the performance of the trees under various treatments. Mr. Partridge presented a paper on this subject to the Society last year, and other writers have contributed their views on the same subject from other angles of approach. It is hoped that this paper will be a valuable addition to what others have done and said.

A word of explanation in the beginning as to the material used in this study will suffice, so that further along the mere mention of a project by number will indicate to the reader just what trees are meant and under what conditions they are handled, their age, etc. It is all taken from Projects 215, 216, 338, and 461 of the Pennsylvania State College School of Agriculture and Experiment Station.

Project 215, in Adams County, trees planted in 1900, varieties York Imperial and Stayman Winesap. There are 16 single-row plots of 10 trees each, of which six are York Imperial and four are Stayman Winesap. Six of these plots have not been fertilized, having been used as "checks"; two rows have received annual applications of phosphorus and potash since 1908; and the remaining eight plots have received nitrogen either alone, or in combina-

tion. Whether alone, or in combination, the nitrogen was applied at the rate of 50 pounds of the element to an acre. Records used in this paper are for gain in trunk circumference from measurements made in 1907 to those made in 1917, and for total pounds of apples produced in the years 1908 to 1918, inclusive.

Project 216, in Franklin County, trees planted in 1900, varieties York Imperial and Jonathan. The layout and treatment are identical with those of Project 215, but the varieties are evenly divided, there being five trees of each in every row. Records used herein are for gain in trunk circumference from 1907 to 1920, and for total pounds of fruit produced in the years 1908 to 1920, inclusive. The lay of the land is more uniform in appearance than in the Adams County project. It is on record that during the earlier years of the conduct of this experiment the inter-planted peach trees were heavily fertilized, even in those rows wherein the apples were not to receive any fertilizer.

Project 338, in Lawrence County, trees planted in 1889, variety Baldwin. Here the number of plots is ten, four of which are "checks," while one has received annual applications of phosphorus and potash and the other five some form of nitrogen at the same standard rate as elsewhere. Records used herein are for gain in trunk circumference from 1910 to 1918, and for total pounds of fruit produced in the same years, inclusive.

Project 461, in Franklin County, trees planted about 1895, varieties York Imperial and Baldwin in alternate rows. This differs in plan and has received more diverse treatments than have the other three. In one plane the area is divided into three strips of four rows not fertilized, four rows treated with stable manure, and four rows treated with a complete fertilizer. At right angles to this division, three plots of twelve trees each have had annual cultivation with no cover-crop seeded, three have had annual cultivation with cover-crop seeded, three have been in sod with straw mulch, and three in sod with no mulch. Records herein used are for gain in trunk circumference from 1912 to 1920, and for total pounds of fruit produced in the same years, inclusive.

In each of these four projects a number of trees have died, and a number have been dropped from the records because of some abnormalities which seemed clearly not to have been the result of the addition, or the withholding, of fertilizing material. This will account for the fact that the numbers of trees to be presented further on in this discussion will be smaller than a full stand in each project as outlined.

We first determined the correlation between trunk circumference, in inches, and total fruit produced, in pounds, regardless of variety or treatment; then for each variety alone, regardless of treatment; then for each variety divided on the basis of treatment into two groups; those to which nitrogen was applied, and those to which it was not. In the case of Project 461, the separation was made on the basis of sod or cultivation. To all these were added the coefficients of variability for circumference and yield. The results obtained have been tabulated by groups in Table I.

TABLE I

Coefficients of Correlation Between Inches Gained in Trunk Circumference and Pounds of Fruit Produced, Together with Coefficients of Variability for Circumference and Yield.

Number of Project	Varieties	Number of Trees	Treatment	Coefficient of Correlation	Coefficient of Variability	
					Circumference	Yield
	GROUP I:					
215	Both	151	All	.72±.026	19.14± .76	40.13±1.79
216	Both	147	All	.56±.038	16.81± .66	32.53±1.41
461	Both	126	All	.41±.050	20.00± .88	34.76±1.64
	GROUP II:					
215	York Imperial	90	All	.64±.034	14.62± .75	36.91±2.09
216	York Imperial	74	All	.62±.048	16.82± .95	39.23±2.48
461	York Imperial	66	All	.83±.038	17.00±1.02	33.58±2.18
338	Baldwin	75	All	.50±.075	31.76±1.91	37.19±2.31
461	Baldwin	60	All	.75±.038	11.80± .73	35.77±2.46
215	Stayman Winesap	61	All	.67±.047	18.32±1.15	38.89±2.70
216	Jonathan	73	All	.77±.032	15.75± .87	19.66±1.13
	GROUP III:					
215	York Imperial	47	N.	.56±.067	14.00± .97	34.33±2.74
215	York Imperial	43	No N.	.62±.063	15.59±1.15	38.89±3.23
215	York Imperial	90	Both	.64±.034	14.62± .75	36.91±2.09
	GROUP IV:					
215	Stayman Winesap	29	N.	.73±.058	16.23±1.46	36.20±3.59
215	Stayman Winesap	32	No N.	.79±.045	19.41±1.68	38.40±3.65
215	Stayman Winesap	61	Both	.67±.047	18.32±1.15	38.89±2.70
	GROUP V:					
216	York Imperial	35	N.	.42±.093	12.82±1.04	28.44±2.45
216	York Imperial	39	No N.	.73±.049	15.07±1.17	49.01±4.48
216	York Imperial	74	Both	.62±.048	16.82± .95	39.23±2.48
	GROUP VI:					
216	Jonathan	35	N.	.44±.09	14.81±1.21	24.13±2.03
216	Jonathan	38	No N	.67±.059	16.17±1.27	26.52±2.17
216	Jonathan	73	Both	.77±.032	15.75± .87	19.66±1.13
	GROUP VII:					
338	Baldwin	38	N.	.307±.099	22.78±2.47	24.52±1.99
338	Baldwin	37	No N.	.309±.100	26.60±1.06	32.35±2.76
338	Baldwin	75	Both	.504±.075	31.76±1.91	37.19±2.31
	GROUP VIII:					
461	York Imperial	32	Cult.	.47±.131	15.23±1.31	29.98±2.74
461	York Imperial	34	Sod	.53±.083	17.76±1.49	37.96±3.52
461	York Imperial	66	Both	.83±.038	17.00±1.02	33.58±2.18
	GROUP IX:					
461	Baldwin	32	Cult.	.72±.055	13.18±1.12	30.48±2.79
461	Baldwin	28	Sod	.50±.093	14.83±1.36	40.47±4.20
461	Baldwin	60	Both	.75±.038	11.80± .73	35.77±2.46

An examination of Group I fails to reveal any striking information. There is one suggestion in the order of the correlations, the highest being that of .72 in Project 215, the next that of .56

in 216, where the trees were the same age, but the records included two additional years, and the lowest correlation, that of .41, in Project 461, where the trees were considerably older. In the first two cases the records date from the earliest bearing of fruit, while in the other case the trees were bearing a considerable amount of fruit when the taking of records was begun. This might seem to uphold the beliefs of certain investigators that significant correlation exists in young trees, but that circumference records lose much of their value when trees begin to produce larger crops of fruit. The fact that the correlations found in Project 338, where the trees are still older, are even lower, adds strength to this belief so far as correlation alone is considered, but we shall show that the value of the circumference records is not lost.

In Group II the behavior of separate varieties in the several locations and regardless of treatment are studied. Here the correlations are quite high and fairly uniform with the exception of the Baldwins in Project 338. For this exception one explanation has already been made in that the trees are the oldest under consideration, and it might be added that they are in a distinctly different geographical situation from the other three, it being in the extreme western part of the state while the other three are all situated in two adjoining southern-tier counties in the eastern part of the state.

Figures are given for York Imperial in three places, Baldwin in two places, and for Stayman Winesap and Jonathan in one place each. Aside from the fact that there is a fairly even range of correlation and of coefficients of variability, with exceptions for which explanations might be offered, it is apparent that no remarkable truth has been brought out either where the varieties are considered together or where no separation was made regarding the fertilizer used on a given variety.

Groups III to VII are to be considered together. The trees of each variety have been divided into two parts according as they received or did not receive nitrogen as a fertilizer, and in each group the figures for the variety regardless of treatment are repeated for purposes of comparison. This division seems justified in view of the cumulative evidence that nitrogen is the important element in orchard fertilization, and it was found possible to make both sides of this division contain half the number of trees of the whole group.

One thing stands out prominently: These five groups agree in that the correlation is higher without nitrogen than with it. Likewise the coefficients of variability in both circumference and yield are higher without than they are with nitrogen. This agreement in five instances on all of three points indicates strongly that the application of nitrogen lessens the degree of correlation between growth and yield, and further on in this discussion will be shown additional evidence pointing to the conclusion that nitrogen, while it increases both yield and circumference, increases yield at the more rapid rate.

In these five groups, when we compare the nitrogen and no-

nitrogen divisions with the combination of both, we find that no uniform relation exists either in correlation or in variability. It seems clear, then, that whatever value circumference records have in conjunction with yield records will be brought out only when studied in connection with separate varieties divided according to the treatment given them.

Groups VIII and IX are included in this report rather because they lead to no conclusion than for any other reason. In project 461 there seems to be no clear division according to fertilizer treatment that would not reduce the number of trees to very small numbers, and so this one separation was made on the basis of culture rather than of fertilization. The cultivated York Imperials are lower in correlation and higher in both coefficients of variability than are those in sod. The cultivated Baldwins are higher in correlation and in both coefficients of variability than are those in sod. They thus disagree in the order of their correlations although they agree in the order of their variabilities. In both varieties the correlation is higher for the combination of all in cultivation and sod than for either of the divisions alone.

The one thing selected for further elaboration at this time is the reduction of the correlation where nitrogen was supplied to the trees. A simple expedient was hit upon first to find the number of pounds of fruit produced for every inch of gain in trunk circumference. In each of the five cases where higher correlation was found with no nitrogen, the inches of gain in circumference made by the individual trees were added, and likewise the number of pounds of fruit produced. The summation of the pounds was then directly divided by the summation of the inches and the quotient taken to be the pounds produced by one inch of growth. The results thus obtained are given in Table II.

In the first, second, and last cases, Table II, it will be seen that where nitrogen is used, every inch in growth in trunk circum-

TABLE II

Showing the Total Inches Gained in Circumference, Pounds of Fruit Produced, and Their Average in Pounds of Fruit Produced per Inch of Gain.

Number of Project	Variety	Treatment	Number of Trees	Total Inches	Total Pounds	Pounds per Inch Gain
215	Stayman Winesap	No nitrogen	32	522.8	80723	154.40
215	Stayman Winesap	Nitrogen	29	511.7	85618	167.32
215	York Imperial	No nitrogen	43	897.0	144684	163.52
215	York Imperial	Nitrogen	47	1002.3	179788	179.46
216	York Imperial	No nitrogen	39	734.5	143810	195.7
216	York Imperial	Nitrogen	35	772.9	152433	197.2
216	Jonathan	No nitrogen	38	795.7	160849	202.14
216	Jonathan	Nitrogen	35	792.0	158626	200.28
338	Baldwin	No nitrogen	37	215.8	84631	392.17
338	Baldwin	Nitrogen	38	332.9	141075	423.77

ference was accompanied by a significantly greater production of fruit than were nitrogen was not used, the differences being 12.92, 15.94, and 31.6 pounds per inch, respectively, in favor of the use of nitrogen.

In the other two cases, dealing with York Imperial and Jonathan, in Project 216, the results are not significant, the York Imperial slightly strengthening the theory and the Jonathan tending to detract from it. Here, however, may be offered the explanation that the interplanted peaches were in the early years of the experiment fertilized heavily, and in spite of some thirteen years' handling of the apple trees as described in the beginning of this paper, one untreated plot ranks second highest in yield in the entire experiment for the full period. The soil, therefore, is still relatively high in fertility even where we have added nothing to it and, perhaps, cannot be expected to show much variation in production or growth. The word "perhaps" is used for the reason that these same York Imperials are selected as the example to prove the theory by the next method to be shown.

In searching out a graphic method for the purpose of learning where nitrogen exerts the influence that lowers the correlation, it was decided to plot the performance of the individual York Imperial trees, Project 216, on one sheet of coordinate paper, representing the inches of gain in trunk circumference as ordinates and the pounds of fruit produced as abscissae. These trees were selected as the example for the reason that they showed the greatest variation between nitrogen and no nitrogen in the correlations.

The problem, then, was to find the two straight lines which most nearly fit these two series of points. Inasmuch as the general equation of the line, $y = b + mx$, has only two constants to be found, and there are several pairs of values of x and y, it is evident that different values of b and m would be found by choosing different pairs of this equation. It is, therefore, desirable to get the most probable values, and we form the normal equations as directed in the theory of least squares, the solution of which gives, for no nitrogen, b equals 13.7 inches, and m equals .556, and for nitrogen-fed trees, b equals 19.2 inches, and m equals .265.

Were these two equations represented by a graph, it would be seen that the line for no nitrogen has the lower point of origin on the y axis and the steeper slope upward, so that the two lines draw together and intersect. This indicates quite clearly that the nitrogen, which was by other means found to lower the correlation, does so by the relatively more rapid increase it makes in production of fruit, rather than in growth of the tree.

This is taken to mean that because one-half of this group of trees were supplied with nitrogen above that which was naturally available to them all, there was an increase in the growth of the trees as measured in trunk circumference, but an even greater proportionate increase in yield of fruit caused, presumably, by the element nitrogen.

There is always a danger of concluding too much from a given amount of evidence, but a great deal of unused material is avail-

able to us for following up the same line of proof; and of this we hope to take advantage. A note of caution comes in also by way of some unpublished notes made by Prof. R. D. Anthony when he was studying the Rome Beauty orchard reported in Geneva Bulletin No. 460. These notes indicate a possibility that the ratio between trunk circumference and tree-top volume might differ in trees receiving nitrogen from the ratio in trees not receiving nitrogen. But the evidence there was not considered sufficient to warrant its being published, and it is not in any sense taken, as it stands alone, to modify the conclusion of the present work.

Summary

1. There is a high degree of correlation between trunk circumference and yield of fruit in apple trees.
2. The indications are that this correlation may grow less as trees grow older.
3. In some cases one variety grouped with another, or one treatment grouped with another, strengthened the correlation; in other cases such grouping lowered the correlation.
4. A single variety failed to show the same degree of correlation in different geographical locations
5. In order to arrive at a fair basis for the comparison of results it was necessary to deal with single varieties in single locations, and to further limit them according to treatment given.
6. Nitrogen was found to lessen the degree of correlation in every instance where it was compared with no nitrogen.
7. This lowering of the correlation by the use of nitrogen is due to the fact that nitrogen increases the fruit yield at a relatively greater rate than it increases trunk growth, when compared with trees not receiving nitrogen.

Conclusion

In-as-much as trunk circumference records used in conjunction with records of the production of fruit, have enabled us to reach certain truths that had not been discovered by our study of production records alone, we conclude that trunk circumference records do have a decided value which may closely approach the value of the yield records themselves as an aid to the correct interpretation of results in apple orchard experiments.

Orchard Soil Management Studies in Indiana

By L. Greene, *Purdue University, Lafayette, Ind.*

THE orchard soil management experiments in Indiana were inaugurated in 1910 by the Indiana Experiment Station in cooperation with the Laurel Orchard Company at Laurel, Indiana. This orchard of 200 acres was planted in 1909 on soil that had been

in pasture for a period of nearly 40 years. During the season of 1909 the land was planted to potatoes; wheat and clover were seeded in the fall of 1909 and clover occupied the ground in 1910.

The various treatments on the 17 acres which make up the plots were begun in 1910. The whole area was cultivated prior to the various seedings.

Professor C. G. Woodbury, former Head of the Horticultural Department at Purdue, later Director of the Indiana Experiment Station and now Director of the Raw Products Bureau of the National Canners Association, planned and inaugurated the work. A year or two later Professor Joseph Oskamp was employed and had charge of the field work until March, 1920, when he left the Experiment Station to become Horticulturist at the Missouri Fruit Experiment Station, at Mountain Grove. Since March, 1920, Mr. F. P. Cullinan of the Purdue Station staff has had charge of the field work. At the time these experiments were started it was felt that to avoid the exclusion of any fundamental factors it would be necessary to take into account soil chemical and bacteriological problems under the different treatments. For the purpose of these studies Mr. H. A. Noyes was employed. His employment continued until the fall of 1918 when he accepted a fellowship with the Melon Institute at Pittsburgh.

The writer has given this list of workers to indicate that he has in no way had anything to do with the active prosecution of this experiment. Unfortunately those who inaugurated and carried on this work for a period of ten years have all severed their connection with the Indiana Experiment Station and no one now in charge has had more than three years' connection with it. This report then deals with the work of other investigators to whom credit for the valuable data secured is due.

The object of the experiment if rightly interpreted, was to study the effect, and the causes underlying such effect, upon apple trees, of different methods of soil management including tillage with cover crops, mulch and sod. No thorough investigation of fertilizers has been included. Since 1913 a complete fertilizer has been used on a few trees under each treatment to determine whether or not the lack of any element of plant food was limiting growth or crop production.. This has been a ten pound application of a 4-7-6 fertilizer except the last two years when the amount was increased to 14 pounds per tree. To date no consistent differences have been noted from the use of the fertilizers. The application of fertilizers has a marked effect upon the grass about the trees, but apparently no differences can be noted on tree growth. Mr. Schultze, the manager of the Laurel Orchard Company, has been using five pounds of nitrate of soda on some of the trees outside the experiments during the years 1919 and 1920. This application of sodium nitrate has produced very marked response in growth and apparently in production, although no careful measurements have been made. Attention should be called to the fact that 14 pounds of fertilizer per tree containing 4 per cent nitrogen is only approximately .5 pound of nitrogen per tree while

five pounds $NaNO_3$ would mean .8 pounds per tree. In the light of investigations reported since this experiment was started, we might not expect a pronounced response to this application.

The treatments given are as follows:

Plot A. Clean cultivation with cover crop for the entire period.

Plot B. The same treatment as Plot A until 1916 when the plot was seeded to grass and since that time has been permanently in grass which is cut and allowed to lie where it falls without outside mulching material.

Plot C. Permanently in sod with the grass cut and allowed to lie where it falls using as a supplement an adequate mulch of straw during the entire period. One bale of straw was used at the beginning and this has been increased to two full bales per tree at the present time.

Plot D. Permanent sod in which the grass is mowed and allowed to lie where it falls.

Plot E. The grass which is cut is raked about the trees. Since 1916 a supplemental mulch of straw has been supplied.

Plot F. In which the grass has been cut and raked about the trees as mulch during the entire period.

Two other plots have been included in the investigations to check on commercial methods and to determine differences between rather level upland and hillside culture nearby. These, however, do not affect the results of the treatments outlined above and will be omitted from this report.

Table I is presented herewith to show the results of these investigations to date. This table covers the period from 1915 to 1920 inclusive. Complete details as to the behavior of these trees during their non-productive period will be found in Purdue University Experiment Station Bulletin 205. The table here presented includes the growth record as determined by trunk girth and the average annual crop production. Other data are omit-

TABLE I

Growth and Production Records For Period 1916-1920

Systems of Management	Plot	Number of Trees	Girth Gain in centimeters. Total for 6 years	Production in pounds. Total for 6 Years	Barrels fruit per acre 1915-1920	Barrels fruit per acre 1920
Clean culture cover crop	A	73	36.87	360.83	87.7	40.0
	B	39	29.52	122.24	29.7	10.1
Straw mulch, grass cut, let lie	C	38	36.37	337.89	82.1	37.7
Grass cut, let lie	D	50	27.02	51.45	12.5	8.3
Grass cut, piled about trees	E	32	32.75	163.38	39.5	22.6
Grass cut, piled about trees	F	45	29.91	78.94	18.9	4.5

ted from this report as the table will give a general idea of the results. Complete data will be published at an early date.

The cultivated and mulched plots stand first and second respectively in growth and production and have maintained these positions consistently throughout the life of the experiment. In growth these plots have made, during the last six years, about 38 per cent greater gains than those which have been permanently in sod without any supplemental material. In production, these plots show about seven times the production of the straight sod plot. To indicate that these are consistent differences it is interesting to note that the production in 1919 on these plots was about ten times that of the permanent sod plot, and in 1920 was about five times that of the permanent sod plot.

One of the striking results of these experiments is the behavior of Plot B, which, it will be remembered, was seeded to grass after having been cultivated until 1916. In only one year since it was seeded has it made as great a girth gain as did the plot which has been in permanent sod. Its relative position in production is gradually falling below that of the permanent sod plot. In 1920 it produced only seven pounds per tree more fruit than did the straight sod plot. Quite frequently the seeding of a cultivated orchard at the fourth to sixth year of its life is recommended for the purpose of checking its growth and throwing it into bearing. There can be no question that the seeding checked the growth of these trees, but to date it has not indicated that such checking of growth has increased the bearing habit of the tree. Most assuredly the permanent sod has been an injury to these trees.

Almost as striking results were secured where a supplemental mulch of straw was added to Plot E which had previous to that time had the grass raked about the trees. This plot had the same treatment as Plot F previous to 1916. At the time the bulletin above referred to was published, these plots were approximately equal in growth up to the time of the addition of the straw mulch. The average growth since 1915 on the plot which has had the supplemental straw mulch has been increased 21 per cent over the straight sod plot and approximately 10 per cent over Plot F which had had the same treatment prior to 1916.

Plot E where straw mulch has been supplied in addition to the grass raked about the trees has gradually increased in production until in 1920 it was 60 per cent of that of the cultivated and straw mulch plots.

The question will arise as to the relative economy of these different methods of soil management. The total production of fruit over the entire period shows that the cultivated plot has produced 86 barrels of fruit per acre about 40 of which were produced in 1920. The straw mulch plot has produced 82 barrels of fruit, 38 of which were produced in 1920. Plot D which has been in straight sod has produced only 12 barrels of fruit, eight of which were produced in 1920. As compared with the straight sod plot, the increased production of fruit in 1920 alone on the cultivated and straw mulched plots, would cover the cost of production over

the entire period and leave a good net profit, so far as the soil management is concerned. Cultivation for five years as practiced in Plot B, which has since been in sod, would show an economic loss as compared with straight cultivation or straight straw mulch.

What definite conclusions can be drawn from these experiments? The writer prefers to call attention to a few important factors leaving the complete interpretation of the results to be brought out in discussion, or later publications.

First, it should be emphasized that no single experiment on one type of soil, can produce conclusive evidence as to the one best method of orchard soil management that might apply to orchards in different regions on totally different soil types.

Second, the Indiana orchard soil management experiments together with those reported from various other states indicate that soil moisture is one of the most important limiting factors in orchard production. In fact the results would indicate that soil moisture under many conditions is the limiting factor. Without sufficient moisture, available food materials are not utilized by the tree. The transpiration experiments to be reported on by Mr. Cullinan indicate that even with a sufficient supply of plant food, without moisture, plants do not make satisfactory growth. It is not desired to minimize the importance of a sufficient and available supply of plant foods in the soil. We must all recognize that satisfactory plant growth cannot be made without such an available supply. On the majority of orchard soils, however, as covered by experiments in many states, plant food has not been a limiting factor where soil moisture has been properly conserved. The remarkable results secured by the use of nitrate of soda within the past few years, have had a tendency to induce investigators and orchardists to conclude that through the application of nitrates the bad effects from the use of sod culture might be overcome. Emphasis should again be placed upon the fact that commercial fertilizers, even in the form of nitrates, cannot permanently replace the necessity for conservation of soil moisture Nitrates in sod orchards are unquestionably very important and the discoveries of recent years have been a boon to commercial fruit production, but the Indiana soil management experiments emphasize the importance of maintaining a satisfactory moisture supply under any and all conditions. An interesting sidelight on this question is brought out by the behavior of two of these plots, one which was cultivated for five years and then seeded to grass has been so stunted as to become the poorest plot in the orchard, so far as growth is concerned. The plot which has received a supplemental straw mulch during the same period has gradually increased in both growth and production until in 1920, the growth is practically equal to that of the cultivated and straw mulched plots, and production as noted before is 60 per cent of the two plots. Most assuredly the opposite results secured on these two plots are due to soil moisture conditions rather than to plant food conditions alone.

Third, the results of these experiments indicate as do other

similar experiments that growth and production are very closely coordinated, and more important, they indicate that on this particular type of soil which is not high in fertility a checking of the growth is not desirable in order to throw the trees into bearing. This might not apply on more fertile soils.

Fourth, under the conditions of the experiments at Laurel two types of orchard soil management have supplied moisture in sufficient quantities to produce sufficient growth to show profitable production. These two are clean cultivation with cover crop, and straw mulch applied at the rate of from 75 pounds per tree in the early history of the orchard to 150 pounds per tree during the later years.

To further summarize these deductions and make them applicable over a wider range of soils and conditions, it may be concluded that some system of orchard soil management which will supply moisture and plant food, is essential to success. Where cultivation can be practiced without erosion, the writer believes it will undoubtedly prove to be, in most cases, the most economical method of orchard soil management. Under certain conditions of cheap mulching material the straw mulch will undoubtedly prove more economical than will cultivation.

In many of our orchard areas mulching materials are very scarce and cultivation is out of the question on account of the rough nature of the land. Under such conditions some system of management which will prevent erosion and at the same time conserve soil moisture, is necessary. It is altogether probable that a sufficient amount of mulching material can be grown between the trees if the entire orchard area is fertilized for grass production, as shown by Professor Ballou in southern Ohio.

One of the dangers which confronts the practical orchardist who adopts the sod mulch method, is that it is very easy to neglect the supply of mulch material necessary to properly conserve moisture, and the trees will suffer accordingly. In other words, sod mulch is the system of the careless orchardist, and while when rightly used it will probably produce as good fruit with better color at very near the same net profit per acre, it is a system which needs careful attention to be made successful.

Preliminary Report on the Effect of Fertilizers in Apple Orchards in the Ozark Region

By J. R. COOPER, *Experiment Station, Fayetteville, Ark.*

SO many factors are involved in the study of soil fertility in connection with fruit production, so much time and labor are necessary to follow out the wide range of major and minor projects which arise, such apparently small factors so often assume mighty proportions and so many wide trails end only in blind

alleys that it is only by united effort that much headway can be made.

The only excuse for the present paper is that it may offer some suggestions or excite some comment which may lead to valuable results.

Allow me to say, and without apology, that among other phases of fertilizer and nutrition work we are carrying on some of the "old familiar plot series fertilizer experiments" with five complete series, of elements used alone and in every known combination in bearing apple orchards, three series in young orchards not yet in bearing, two series in bearing peach orchards, besides the work in vineyards and strawberry fields. We are at the same time attempting to follow up the may-or-may-not-be more fundamental work with individual plants and portions of plants.

One thing alone offers sufficient excuse for the "plat series" phase of work—we must finally stand for judgment before the practical grower and answer the question "does it pay." If we can at the same time determine for our own satisfaction the "how" and the "why" we will be doubly blessed. The time during which our work has been under way is altogether too short to make any definite statements in regard to any phase of the work. We have, however, made many interesting observations which are indicative.

As is the case with most other fertilizer experiments on apples, nitrogen has given us the greatest promise of direct results. The reason for this is at least indicated by the valuable work of Kraus and Kraybill. Among other things we have been able, in orchards growing on poor, leachy soils, to increase our set of fruit from 1½ to 10 per cent with 40 per cent of the spurs blooming, and from 1 to 5½ per cent with 81 per cent of the spurs blooming. We were also enabled to carry a large per cent of fruit which did set through to maturity. In making our records no examination for set of fruit was made until all danger of the June drop was over. The effect was less pronounced in orchards where soil conditions, tree growth, and previous performance indicated the presence of more nitrogen in the soil, while in our orchards which had received heavy dressings of manure both of the previous seasons, little or no benefit was shown. In fact in one of these orchards, where nitrogen of soda was also applied the previous season, our check plots showed a higher set than the fertilized plots. No effect on the set of fruit was observed from the use of either phosphorus or potash.

We have of course encountered a number of other factors having an important bearing on the set of fruit. We have been able by judicious pruning to stimulate the effect of nitrogen for a single season. We have, however, demonstrated to our own satisfaction that we cannot continue the practice of pruning to procure a set of fruit, successfully. The tendency toward alternate bearing, the individuality of the tree, and of the different parts of an individual tree must all be considered. Our observations have led us to believe that the whole tree performs as more or less of a unit and that the difference in performance of different parts is due largely to location with regard to food and water supply

and other conditions of environment. Roberts in his valuable work on "Off-year Apple Bearing and Apple Spur Growth" has grouped spurs into four classes; first, short or leaf spurs (1/8 inch long); second, spurs bearing blossoms but not fruit (3/16 inch long); third, spurs which set fruit (1/2 inch long); and spurs 3/4 inch and over which bear only leaves. We found all of these groups represented. The group under which we found our spurs falling seems to be determined very largely by the position which it occupies on the branch. The general vigor and condition of this branch we find to be modified more or less by the position it occupies on the limb. The limb is likewise influenced by its position on the trunk in regard to proximity to other limbs, its point of origin in relation to these other limbs, and in relation to the feeding roots. The amount of light available also bears a decided influence on spur growth. Our record of spur growth follows very closely the description given by Roberts. It seems to us, however, that there is more mass than individual action and that the performance of different classes of spurs is due largely to location and finally to the available supply of plant food. We have been able to change the performance of these spurs by pruning. Pruning, however, affects only a very limited area in close proximity to the cut made and does not at all correspond to the size of the cut. Our greatest change has been effected by controlling the water and nitrogen supply. By modifying these factors, while it may not change the general grouping to a great extent, we have turned a great many buds from classes one and two into classes three and four and many of class three and a very high percentage of class four into rapidly growing branches.

In carrying our investigation further, we find that even different flowers on the same spur, and often different parts of the same flower, respond differently to heavy nitrogen feeding. The vitality of pollen taken from flowers on different parts of the tree varies to considerable extent. Using the percentage and rapidity of germination of pollen as a standard, we have been able to increase the vitality of pollen of a number of different varieties both by pruning and by the early use of quickly available nitrogen. The latter method has given us the most decided and uniform results. The average germination from a large number of tests of different varieties of pollen from unfertilized trees in 1919, was 45.5 per cent in 4 hours, from fertilized trees 57.4 per cent in 4 hours. Pollen tests from the same varieties and the same trees in 1920 gave a germination of 24 per cent for unfertilized and 35.3 per cent for fertilized trees. The generally poorer vitality of pollen in 1920 was no doubt due to the severe freeze which occurred over the Ozark region on Easter Sunday. The results of germination tests would indicate that the addition of nitrogen played some part in the reduction of frost injury. In checking the set of fruit on the different plots it was found generally higher in 1919, but more difference was found between the check plots and the fertilized plots in 1920. On varieties nearly or partly open at the time of the freeze, slightly more frost injury was found on unfertilized

trees, and on trees where breeding work was being carried on more injury was found on trees carrying a heavy bloom than on trees with a moderate amount. Contrary to what might be expected, however, less injury was found in the sod portion of one of our orchards than in the clean cultivated portion.

Another point which may be of some interest is that in a few cases where excessive amounts of nitrogen were used there was considerable distortion of flower parts. In the majority of cases the petals and stamens suffered more than the pistils. There was considerable twisting and distortion of anthers. Pollen germination tests showed a decrease in vitality.

The number of well-developed seeds has been found to bear quite a distinct relation to the size of the apple. The thoroughness of pollination, hence the abundance and vitality of pollen, we have found to have a very important bearing on the development of seeds. While considerable damage was done by the freeze on Easter Sunday of this year, the weather was much more favorable for pollination than during the blooming period of 1919.

Considerable difference in color and size of fruit was noticed in connection with fertilizer tests. Here again, however, the individuality of the tree played an important part and it was only by the use of large quantities that comparison could be made. There was a tendency toward poorer color on all nitrogen plots than on those without nitrogen. The fruit matured somewhat later and was considerably larger in size. The greatest difference in color was noted on plots where nitrogen was used alone.

In closing, it should be noted that only the results of observations have been given and that no attempt has been made to explain results. Both criticisms and suggestions will be welcomed.

Responses of a Young Peach Orchard to Certain Cover Crops and Fertilizer Treatments

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THE experiments on which the responses described in this paper were observed were conducted in a peach orchard located near Olney, in Richland County, Illinois. The location is near the east side of the state in the same latitude with the city of St. Louis. The orchard slopes gently and regularly towards the west. The site is on the side and near the top of a ridge of somewhat unusual prominence for a prairie county. The soil is a gray silt loam on rather tight clay subsoil. The drainage is good, but falls considerably short of being ideal. The soil is poor in humus, low in nitrogen and phosphorus, and high in potassium. Illinois soil survey analyses show that this type of soil contains about 2,700

pounds of nitrogen, 750 pounds of phosphorus and 24,800 pounds of potassium per acre in the surface soil.

The orchard is divided into 43 major plots, each of which includes 16 trees. The plots are arranged in 3 ranges, each range separated from the adjoining one by a wide space where 1 row of trees was omitted. The plots in the range are separated by division rows of a separate variety. Each plot consists of 2 rows of trees of the variety J. H. Hale. The separating rows are Elberta. The trees were started from June-buds planted in the spring of 1917. An unusually uniform stand was obtained and the orchard has had no set-back due to unfavorable weather, insect or disease visitation, or other accident to interfere with an impartial response to the treatments given.

Following a favorable winter for both wood and buds, the orchard set a good crop in its fourth season of growth and showed differences between the yields of certain of the plots large enough to bear significantly upon certain orchard practices with reference to cultivation, cover crops, and fertilization for young trees growing on similar types of soil.

The effects of cover crops were striking and unexpected. Eighteen plots were sown annually with cow peas following a period of clean cultivation lasting from early spring till July 10 to 15. A good stand was obtained each year and the crop residue was disked in with the first cultivation the following spring. Direct observations of the effects of cow peas used as a cover crop were obtained in 4 widely separated pairs of plats with the results very decidly favoring cultivation alone. The comparisons follow: First pair (plats 103 and 203) 74.7 pounds per tree as compared with 56.6 pounds per tree; second pair (plats 107 and 207) 60.5 pounds per tree as compared with 48.8 pounds per tree; third pair (plats 111 and 211) 52.2 pounds per tree as compared with 35.5 pounds per tree; fourth pair (plats 307 and 303) 52.1 pounds per tree as compared with 35.6 pounds per tree. The averages for the 4 pairs of plats show that clean cultivation outyielded cultivation and cow pea cover crops by 32 per cent or practically one-third. Interpreted in yields per acre, this difference favored clean cultivation over cultivation and cover crops by 2,000 pounds for trees only in their fourth season of growth.

I would hesitate to present the above results from a single season's work were the difference not marked and consistent for each comparative pair of plots. Further, the trees in the 4 cover crop plots were smaller in size and less vigorous in foliage than those under clean cultivation, differences which began to be observable during their third season's growth.

Even more striking effects followed the use of cow peas and rye as green manure and cover crop on the same plat. To test the probable advantages of cow peas as a source of nitrogen, and rye as a living winter cover which would effectively prevent soil washing, cow peas were sown on 6 plats between July 10 and 15 each year. The cow peas were disked about October 1, and rye was sown immediately. Good stands of cow peas and rye were obtained

each year. In 1918 the rye was worked into the ground early in the spring, after reaching a height of 10 to 12 inches, and in 1919 and 1920, when not over 6 or 7 inches tall. Each of the 6 plats thus treated yielded less than the corresponding clean cultivated control plat, while their average yield per tree was but 27.9 pounds compared with 44.3 pounds for the control plat. Compared with the average of all the clean cultivated control plots in the orchard (5 in number) the cow pea and rye plats yielded only 27.9 pounds per tree compared with 60.5 pounds for the clean cultivated plats, or 116 per cent more than the cow pea and rye plats.

The trees in the cow pea and rye plats are stunted, lacking in vigor, and pale in foliage. The fruit ripened a full week earlier than the fruit in the clean cultivated plots and 10 days to 2 weeks earlier than the fruit in certain fertilized plots. A continuation of this treatment seems likely to result in the early death of the trees.

In view of the fact that the soil in question is low in humus and nitrogen the responses of the trees to the cover crop treatments suggest a search for reasons to explain their behavior.

Exhaustion of moisture at once suggests itself as a possible explanation for the behavior of the plats. The soil, which is not deep, is fairly easily affected by drought, a fact that at first glance lends some encouragement to this theory. But this theory cannot apply to the effects of the rye as it was sown each year after the trees had completed their season's growth and was disked under so early in the spring that it had not yet drawn upon the reserve moisture supply of the soil, in fact, before the leaves of the trees had expanded. Cow peas sown between July 10 and 15 would not draw heavily on soil moisture before the third or fourth week in August, but it is conceivable that they might interfere with fruit-bud formation after that date by extra draft on the water supply, particularly during a drought in late August or September. However, the moisture theory does not appear to apply to this crop either, because the cow pea plots which were fertilized in certain ways, in addition to receiving the cover crop, compared favorably with, and in some cases outyielded clean cultivated plots similarly fertilized. Comparing 11 cow pea plats treated in a manner identical with 11 corresponding clean cultivated plats (including 3 pairs of unfertilized checks or controls) clean cultivation outyielded cow pea cover crops by only 2 pounds per tree, a negligible amount. Therefore, it would appear that the major causes of the detrimental effects of the cow peas were connected with the plant food supply rather than with moisture supply.

If, therefore, it should be found that the addition of one or more elements of plant food to the cover crop plats overcame the detrimental effects of the cover crop, it would be fair to assume that the cow peas drew on the normal supply of that or those elements to the detriment of the peach crop. And if it should be found further that the addition of one or more elements of plant food to the cover crop plots increased their yield beyond the yield of clean cultivated plots similarly fertilized, it would be good evi-

dence that the humus at least furnished by the cow peas was beneficial.

A comparison of fertilized cover crop plats and fertilized clean cultivated plats throws suggestive light on this phase of the investigation. Three cow pea plats were fertilized with sodium nitrate in contrast to three corresponding clean cultivated plats, with the following results.

All 3 cow pea plats fertilized with sodium nitrate outyielded cow pea plats which were not so fertilized. One yielded the same as the corresponding clean cultivated plat fertilized with sodium nitrate; one yielded slightly less than its corresponding control, and the third decidedly less than its clean cultivated and fertilized mate. Nitrogen, therefore, helped the cow pea plats to overcome their handicap, but was not, on the average, able to supply all the deficiency. Three cow pea plats were fertilized with potassium sulphate in contrast to three clean cultivated plats similarly fertilized. All 3 yielded more than cow pea plats which were unfertilized; two yielded considerably more than their clean cultivated mates; one yielded somewhat less than its clean cultivated partner, but was far in excess of the unfertilized cow pea check. Potassium, therefore, more than made up the deficiency in 2 cow pea plats and went far towards doing so in a third.

Phosphorus in soluble forms was not used on corresponding cow pea plats and clean cultivated plats. It was, however, applied in various and inorganic forms to a total of 18 plats and in organic forms to 8 more.

Plats 203, 207 and 211 (all cow pea plats) were fertlilized with rock phosphate at the beginning of the experiment and may be compared with cow pea plat 303 which was not thus fertilized. Plats 203 and 207 outyielded 303, and 211 equalled it, leaving a slight balance in favor of the plats receiving phosphorus.

Cow pea plats fertilized with nitrogen, potassium and phosphorus, however, failed to outyield plats fertilized with nitrogen and potassium alone. (Compare plats 201, 212, 213 and 214 with 306.)

Cow pea plats fertilized with nitrogen and phosphorus outyielded plats fertilized with nitrogen alone. (Compare plats 204 and 205 with plat 304.) No comparisons of potassium and phosphorus with potassium alone were made. The highest yielding plat in the entire orchard received no phosphorus in any form. The effects of phosphorus on the cow pea plats are, therefore, inconsistent, and at best indicate only a minor effect in increasing yield.

Four cow pea plats (201, 212, 213 and 214) which were fertilized with potassium sulphate and sodium nitrate (in addition to phosphorus in certain forms) all bore heavily and on the average sligtly outyielded clean cultivated plats similarly fertilized. It is evident, therefore, that the addition of nitrogen and potassium in proper amounts somewhat more than overcame the detrimental effects of the cow peas.

The responses of the peaches to the cow pea cover crops and the various fertilizer treatments indicate, therefore, that over-draft

of the cover crop on certain elements of plant food is the prime reason for the detrimental effect of the crop on the growth and yield of the trees; that nitrogen is one of the elements overdrawn by the cow peas; that potassium is even more seriously drawn upon than nitrogen; that phosphorus is only a minor factor, and that the addition of potassium and nitrogen together will completely correct the ill effects of the cow pea cover crop.

The experimenter regrets that there are no fertilizer treatments crossing the cow pea and rye plats. There is, therefore, no evidence to show that the addition of plant food to this treatment will correct its detrimental, indeed deadly, effects. The following is offered merely by way of suggestion for further investigation. In view of the fact that the rye crop is sown so late in the fall, is cultivated down so early in the spring, and makes so little total growth, and all at a time when presumably tree growth is not very active, it seems very doubtful if the factor involved is a plant food factor. It seems clear too that the factor is not that of moisture. There remains, therefore, but to suggest that there is some incompatible relationship between rye and peach trees due to obscure reactions, possibly toxic in character, which occur where the two plants occupy the same soil.

A summary of the results of the work as it bears on a cover crop of cow peas for young peach orchards on soils such as those described (and the experimenter believes it will generally be found true in other soils as well) follows:

1. Cow peas used as a cover crop planted from July 10 to 15 were detrimental to the growth and yield of peach trees as compared with clean cultivation alone.
2. The addition of a fertilizer carrying soluble potassium completely corrected the difficulty.
3. The addition of a fertilizer carrying soluble nitrogen partly corrected the difficulty.
4. The addition of a fertilizer carrying phosphorus gave uncertain results.
5. The addition of both nitrogen and potassium somewhat increased the yield of cover crop plats over clean cultivation.
6. Rye following cow peas, used as a winter cover, was very detrimental, almost deadly, in effect.

Experiments Upon Apple Tree Nutrition

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IN the course of a study of fruitfulness with especial reference to biennial bearing of apples, it became apparent that this condition was closely related to nutritional conditions. More recent data indicate that blossom bud formation has a definite relation to the nature and amount of reserved materials in the tree. At

any rate, the nutritional or vegetative condition of the trees was found to be correlated with either regular or off year bearing. In view of this fact, success in an attempt to regulate fruitfulness would seem to be dependent upon producing rather definite growth conditions. This principle has been the basis upon which the field experiments on fruitfulness and regular bearing were organized. As a consequence, certain variations from the customary practices, have been introduced. This paper offers an explanation of the methods used. It may be of interest in view of the frequent discussions of the desirability of cooperative projects, to note that companion field plats are being run in cooperation with the Horticultural Department of the University of Maryland.

In outlining the experiments upon the question of fruiting, two important variations from the usual procedure followed in orchard cultural experiments, were made. Pruning, cultivation, or fertilizer experiments, are usually conducted separately. This method did not seem to be the means best adapted to create the conditions of vegetative extension which have been found to be associated with regular bearing. Employment of combinations of these was believed to be the better plan. Not only has the usual procedure of the use of individual fertilizer, or cultural, or pruning effects been abandoned in preference for a combination of some to all of them, but the usual measure of results used—that of bushels of fruit produced—is given a minor place in the taking of data on the plats as now conducted.

Our plan of using combinations of the cultural practices in an attempt to induce desired growth conditions, is criticised from the practical viewpoint, that it fails to show the value of a single cultural practice to the grower. There are two important answers to this criticism. In the first place, the effect of a cultural practice upon yield is a very indirect one and, for our present purposes, is a secondary matter. Our immediate objective is to produce varying conditions of vegetation and to determine the relation between the tree growth conditions and blossom bud formation and fruitfulness. Once these facts are ascertained it will not be difficult to find the effects of a single treatment in creating desired growth conditions and then, practical, and incidentally more accurate, recommendations for the cultural practices can be made.

In the second place, the effect of a certain cultural practice upon yield may be largely a local matter. This is illustrated by the mass of conflicting data now available upon the questions of orchard cultivation, fertilization and pruning. The vast expenditure of time and money upon the conducting of such experiments by experiment stations has in the majority of cases given little more than material for debate. This is especially true where yield has been the principal measure of the results secured.

On the other hand, there is every reason to believe that the relation of growth conditions to fruitfulness is a rather constant matter. If from the experimental plats where various cultural practices have been tried, data had been collected to show the nutritional and growth conditions prevailing at the beginning and

close of the various treatments, whether it be cultivation, fertilization or pruning, it would doubtless be possible to interpret the results as offering little conflicting data and we would have available, now, not only the material for a clearer understanding of the factors associated with fruitfulness of trees, but also a valuable if not wholly accurate basis for cultural recommendations. A cultural experiment has value in a fundamental way only when its influence upon the accumulation of reserve materials, or the correlated growth responses, is known. It is well to know its effect upon the actual yield of fruit secured, but it is more important from the viewpoint of nutrition studies to determine its influence upon blossom bud formation.

As to a better measure of results obtained, it is felt that the formation of blossom buds, as determined in terms of the number of spurs blossoming, is a clearer index of the fruiting condition of the tree than is the yield of fruit. A tree with one-third of its spurs developing blossoms is, to our mind, a vastly different fruiting unit than is the tree with all of its spurs blossoming; yet, in general, each of these two trees can be expected to produce about the same amount of apples. This is because of the fact that with the more heavily blossoming trees, the set of fruit is generally in inverse ratio to the number of spurs blossoming. The yield of fruit as a measure of the ability of the trees to produce blossoms. is also of limited value because it is not only dependent upon the amount of blossom buds present but also upon the effects of pollination, (blossom) fertilization, insect pests, diseases, and mechanical and climatic injury. Most of these are as separate if not as important questions in securing profitable production as is blossom bud formation itself. In fact, any practice, as soil fertilization, may have its effect upon yield through affecting the set of fruit rather than by materially modifying blossom bud formation. In such cases, the specific or fundamental effect of the treatment upon fruitfulness, may be overlooked when yield alone is considered.

Even the trunk diameter of a tree, which more recently is being commonly applied as a measure of cultural effects may indicate more of a quantitative than a qualitative difference as it is apparenly upon quality of composition that blossom bud formation, if not yield, depends. Certainly, it is not safe to assume that quantity and quality of lateral growth are always correlated; and apparently the composition of the plants is a big factor in producing fruiting responses. This was iluustrated by the work of Kraus and Kraybill[1] on the tomato. Similar data for apples have been collected by Hooker[2] and during our own investigations. However, exact knowledge of internal composition of the tree is not necessary in a practical measurement of the vegetative or fruiting condition of the trees. There are correlated growth conditions which answer very well for purposes of experimentation if it is constantly re-

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[1]Kraus, E. J. and Kraybill, H. R., Ore. Exp. Sta. Bul. 149. 1917.

[2]Hooker, H. D., Jr. Mo. Exp. Sta. Res. Bul. 40. 1920.

membered that they are not the factors giving fruitfulness, but are, in turn, only the effects of internal conditions.

Some of these correlated growth conditions are used in measuring the results secured in our field experiments. Especial consideration is given to the percentage of spurs producing blossoms. From the standpoint of measuring fruitfulness, however, it is as important to know the growth conditions of non-blossoming spurs as it is to know the number of spurs blossoming. These unproductive spurs may be either too poorly vegetative or too strongly vegetative to be fruitful. The condition of the spurs should be determined if the results of the various treatments are to be correctly interpreted, for in this case, they represent extremes of vegetative condition although they are both merely unfruitful spurs from the yield standpoint. It is desirable, also, to know the percentage of blossoms setting fruits and the percentage of a crop secured, together with the length of terminal growth made and especially the facts as to whether or not blossom buds are developed on terminals, on fruiting spurs or, as lateral buds, and, more particularly, on spurs of the second year wood. Some other less important measurements are being made. These may even be varied as the problem advances. After measurements have been secured to show the actual state of vegetation prevailing, it is, of course, desirable to measure the yield to determine the economic value of a practice. This measure is, however, of minor importance in trying to find out how and why, in addition to when, a tree is fruitful, and under what conditions it attains maximum production.

A second type of experiment is being conducted with potted trees in the greenhouse. By varying the nutrients used, extremes of vegetative condition are being produced. It is planned that manipulation and study of these trees will give evidence of the accumulation, nature, distribution and utilization of the reserve materials in the wood as well as of the new materials formed during any period of growth. Various measurements and studies are being made. These include chemical analyses in cooperation with the Department of Agricultural Chemistry. A later phase of the work is to observe the influence of pruning and soil nutrition upon the synthesis and storage of such reserve materials as may be found to be present. It is believed these data will aid in the interpretation of field results and formulation of cultural recommendation.

At present it may be stated that, under conditions of low nitrogen nutrition, the type and appearance of foliage and early new growth, is as much influenced by the composition of the wood, as a result of previous treatment, as it is by the current seasonal conditions. This is taken as having marked significance in connection with a study of the reserves of the tree and how they induce, if not regulate, conditions of fruitfulness in apple trees.

Some Responses of Bush Fruits to Fertilizers

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In the autumn of 1913 and the spring of 1914, at the Cornell Experiment Station, plantings were made for a preliminary study concerning the responses to fertilizers of American gooseberries, currants, American red raspberries, black raspberries, and blackberries. The soil, classified by the Bureau of Soils as a Dunkirk clay loam, is not particularly well adapted to the growth of these fruits. It was thought, however, that some evidence as to the peculiar responses of these crops might be secured, and that by means of this a better plan for an experiment concerning the needs of these crops might be arranged. An analysis of soil of this type near this field was made by Lyon and Bizzell. This showed of potassium oxide, first foot 1.830 per cent, second foot 2.360 per cent, third foot 2,610 per cent, fourth foot 2.480 per cent; and phosphoric anyhydride, first foot 0.084 per cent, second foot 0.79 per cent, third foot 0.110 per cent, and fourth foot 0.131 per cent. Analyses for phosphorus were kindly made by these men of soil from the first foot in this planting.

At the beginning the plots, in case of each fruit, were composed of two rows containing twenty-five plants each, the rows being six feet apart and the plants three feet apart in the row. Each plot was thus a little less than one-fiftieth of an acre. In March, 1918, fifteen of the gooseberry plants and ten of the currant plants were removed from each row. The application of any element were given at the same strength on all plots to which it was applied. At the beginning of the experiment, in 1914, when the plants were small, the applications were of potassium chloride 100 pounds to the acre, acid phosphate 400 pounds, and sodium nitrate 200 pounds. By 1920 the applications had been increased until the plots received of potassium chloride 300 pounds, acid phosphate 600 pounds, and sodium nitrate 350 pounds to the acre. Where manure, tankage, or dried blood was used, amounts were applied that would furnish approximately the amount of nitrogen applied to a plot receiving sodium nitrate. Then potassium and phosphorus in the forms mentioned above were added in quantities large enough to bring the amounts of these elements at least up to that applied to plots receiving complete mineral fertilizers. Of course the tankage furnished an excess of phosphorus.

In the spring of 1920 Stowell evergreen sweet corn was planted in those portions of the gooseberry and currant rows where plants had been removed in 1918. Each hill was thinned to three plants. Each row had the same fertilizer treatment that the gooseberry and currant plants in that row had. The corn was thus influenced by the fertilizer applied to it when it was about six inches high, in the summer of 1920, and by the residual of the fertilizer applied to the gooseberries and currants before 1918. Table I

gives the yields of the currants and gooseberries beginning with the summer of 1918, the weight of the corn, and the average weight of the plants removed.

TABLE I

The Effect of Fertilizer on the Yield and Growth of Currants and Gooseberries, as Compared With its Effect on the Growth of Corn.

Treatment	1918 Pounds	1919 Pounds	1920 Pounds	Total Pounds	Average Weight Plants Removed Pounds	Weight Corn (40 Stalks) Pounds
Currants						
Manure	14.75	1.50	38.37	54.62	1.4	....
Manure	13.56	2.50	38.45	54.51	1.2	....
Tankage + K	20.88	3.00	40.67	64.55	1.0	31.80
	13.88	2.50	37.78	54.16	1.0	37.00
NPK	27.81	4.00	51.68	83.49	0.9	22.72
NPK	25.69	3.50	53.24	82.43	1.0	23.12
Check	26.69	4.50	49.72	80.91	1.2	4.68
Check	28.75	3.50	51.40	83.65	1.2	5.08
N	27.31	3.75	49.01	80.07	1.0	2.36
N	26.13	2.25	40.17	68.55	1.0	5.68
P	26.75	4.00	48.36	79.11	0.9	21.76
P	22.81	6.00	49.98	78.79	1.1	17.92
Check	22.56	6.75	53.60	82.91	1.1	4.92
Check	22.88	5.50	59.99	88.37	1.3	10.48
K Cl	17.44	2.25	41.00	60.69	1.2	6.96
K Cl	21.94	4.00	65.87	91.81	1.0	8.12
Gooseberries						(20 stalks)
Manure	31.31	37.00	112.60	180.91	1.8	....
Manure	28.00	29.50	114.70	172.20	1.9	....
Tankage + K	28.25	24.25	76.20	128.70	1.4	....
Tankage + K	16.75	23.75	63.00	103.50	1.7	....
Check	19.38	12.00	56.00	87.38	1.2	5.60
Check	18.25	10.06	50.55	78.86	1.0	2.52
NPK	18.44	11.75	85.25	115.44	1.5	17.92
NPK	18.25	15.00	65.15	98.40	1.5	26.84
N	12.94	11.00	56.75	80.69	1.4	6.00
N	16.06	11.50	67.85	95.41	1.2	10.00
Check	9.56	12.81	66.25	88.62	1.2	7.80
Check	8.63	9.50	55.05	73.18	1.1	11.20
P	11.75	10.50	61.50	83.75	1.2	40.56
P	13.88	10.75	57.70	82.33	1.1	35.84
K Cl	15.56	19.00	74.85	109.41	1.0	9.52
K Cl	5.75	10.50	63.45	79.70	1.2	5.04

It will be seen that the corn showed remarkable response to phosphorus, in fact, corn would grow but little more than twelve inches high without it. Even at the time fertilizer was applied the young corn was showing strongly the effect of phosphorus applied before the gooseberries and currants were removed in 1918. Evidence seems conclusive that in this same soil gooseberries have shown no response to applications of phosphorus.

The soil was not well enough adapted to the growth of blackberries or red or black raspberries to make it possible to determine

TABLE II

Effect of Fertilizers on the Growth and Fruitfulness of Red Raspberries.

Treatment	Yield in ounces			Average cane height in inches			Number of canes			Ounces to cane			Ounces to 100 feet of cane		
	1918	1919	1920	1917	1918	1919	1917	1918	1919	1918	1919	1920	1918	1919	1920
NPK	577	242	116	56.6	51.7	45.2	267	222	347	2.16	1.09	.33	45.8	25.3	8.9
NPK	728	289	166	57.3	52.3	45.2	359	268	492	2.03	1.08	.34	42.5	24.7	9.0
N	777	401	201	67.0	58.4	49.5	582	491	666	1.33	0.82	.30	23.9	16.9	7.3
N	811	382	248	64.6	59.7	49.8	531	455	640	1.53	0.84	.39	28.4	16.9	9.3
CH	671	427	445	60.0	55.4	48.7	359	258	328	1.87	1.66	1.36	37.4	35.9	33.4
CH	650	416	485	61.0	49.9	46.5	417	271	371	1.56	1.54	1.31	30.7	36.9	33.7

whether or not any of them would show some response to phosphorus. Response much less strong than that shown by the corn could have been detected, however. Thus the red raspberries showed very marked response to applications of nitrogen, though the blackberries showed no response that could be measured under these conditions, and with the black raspberries the response, if there was any, was much less than that of the red raspberries. Thus in two plots of black raspberries receiving nitrogen, the total cane growth was 1.004 times that of the two plots receiving no nitrogen; in case of the red raspberries it was 1.870 times that of the plots receiving no nitrogen.

The red raspberry was benefited much less in yield than in growth by the application of nitrogen, as the following table will show.

The variety was Cuthbert, one that suckers very readily, and the nitrogen caused a very thick growth of canes. It is possible, or even probable, that with a variety which does not sucker so readily the greater cane growth would have also resulted in an increased yield to the cane.

By referring to Table I it will be seen that the currants have shown no measurable response to any element. This may be because the soil was not physically well adapted to the growth of currants. The gooseberries have responded to nitrogen and possibly to potassium, but the response to manure has been much greater than that to complete mineral fertilizer. This is in line with the experiments of Pickering with European gooseberries. In case of the Cuthbert raspberry, however, sodium nitrate seemed actually to cause a larger response than was caused by the same amount of nitrogen in manure, tankage, or dried blood.

Pentosan Content in Relation to Winter Hardiness

A New Theory of Hardiness and Suggestions for its Application to Pomological Problems

By HENRY D. HOOKER, JR., *University of Missouri, Columbia, Mo.*

DEATH of plant tissue as a result of exposure to low temperature may undoubtedly be associated with many different factors. The living plant cell is in a condition of mobile equilibrium which can be destroyed by any factor that becomes limiting when the temperature is sufficiently lowered. A study of the literature on hardiness shows very clearly, however, that loss of water is one of the most frequently recurring factors which leads to death on exposure to low temperature. Conversely the ability of plants to withstand low temperatures without injury seems frequently to be associated with the water-holding capacity of their tissues.

In this connection, Spoehr's work on "The Carbohydrate Economy of Cacti" is suggestive. Spoehr found that the pentosan content of Opuntia increases under xerophytic conditions and he points out that pentosans have the power of swelling and taking up enormous quantities of water. An investigation was made, therefore, to discover a possible correlation in fruit plants between winter hardiness and pentosan content. For this purpose shoots of tender varieties of apple, such as Missouri Pippin and Stayman Winesap were compared with shoots of more hardy varieties, such as Wealthy and Yellow Transparent. Short matured shoots of Ben Davis were compared with long immature green shoots of the same variety. Currant shoots were compared with a variety of raspberry tender in this section, namely Cuthbert; in the latter

TABLE I

Pentosan Content of Plant Tissues in Terms of Fresh Weight.

	November 8th	December 2d
WEALTHY—		
Bases	6.52	5.99
Tips	5.41	5.11
YELLOW TRANSPARENT—		
Bases	5.15	5.89
Tips	3.55	5.06
MISSOURI PIPPIN—		
Bases	3.29	4.01
Tips	4.37	4.91
STAYMAN WINESAP—		
Bases	4.72	5.26
Tips	3.28	3.96
BEN DAVIS SHORT SHOOTS—		
Bases	5.64	5.59
Tips	5.19	4.56
BEN DAVIS LONG SHOOTS—		
Bases	3.90	4.04
Tips	2.22	3.79
CURRANT—		
Bases	4.78	5.01
Tips	4.44	3.68
MATURE CURRANT—		
Bases	5.20	4.28
Tips	3.09	3.24
IMMATURE CATHBERT—		
Bases	1.61	Killed
Tips	1.28	Killed

mature shoots were contrasted with immature late growths. Two collections of samples were made, on November 8th and December 2nd between which dates the temperature dropped to 10° F. This killed the immature Cuthbert shoots. In all cases bases and tips were analyzed for mutual comparison and the terminal buds were removed from the shoots before sampling. The analyses for pentosan were made by the procedure suggested by Spoehr. The tissue was hydrolized, made neutral, the hexose sugars were fermented off by yeast and the pentose sugars remaining were determined by the Munson and Walker method, except that the reduced copper was burned and weighed as copper oxide. The data obtained are given in Table I and show an excellent correlation between resistance to low temperatures and the pentosan content. The results are expressed in percentages of fresh weight.

In order to determine whether tissues of different pentosan content actually possess different water-holding capacities, air dry samples of tips and bases of long Ben Davis shoots were placed in desiccators over sulphuric acid of varying concentrations. After eight days the gain or loss in weight was determined. It was found that the bases with a pentosan content of 8.1 per cent of the dry weight lost less water and absorbed more from the atmosphere of the desiccator than the tips with a pentosan content of 5.26 per cent of the dry weight. The results are given in Table II.

TABLE II

Per cent of Sulphuric Acid in Desiccator	Water Lost From Ben Davis			
	Tips		Bases	
	Mg. per gm.	Per cent.	Mg per gm	Per cent
100.00	22.4	100.0	20.4	100.0
73.13	21.4	95.5	17.6	86.2
64.67	12.6	56.2	9.2	45.1
52.13	7.4	33.0	4.8	23.5
43.75	4.0	17.8	2.2	10.8
	Water Gained			
36.69	30.0	134.0	32.6	160.0

It is a commonly observed fact that tender plant tissues usually contain more water than hardy tissues. This has been found by determinations at the Missouri Experiment Station and has been noted by many investigators. If hardy tissues contain more pentosan than tender tissues and consequently have a greater water-holding capacity, why should they actually contain less water? This is accounted for by the fact that the water contained by plant tissues exists in several different forms. Boyoucos distinguishes

three classes of soil water: (1) Free water that freezes at 0° C. or slightly below; (2) absorbed water which freezes at temperatures ranging down to -78° C; and (3) Combined water which freezes at temperatures below -78° C. McCool has applied this classification to the water of plant tissues.

It is our theory that the pentosans, or rather some specific pentosan, functions in the plant tissue by holding water which is in the nature of absorbed or colloidal water, and that this type of water actually does not freeze when the plant is subjected to ordinary winter conditions. The greater water content of tender tissue as compared with hardy tissues would be due, therefore, to an excess of free water. Though hardy tissues contain less free water they contain more absorbed or colloidal water.

If this theory is correct and should be confirmed by further investigations now under way, it may be of great practical importance. Spoehr has shown that the pentosan content of cacti is increased by dryness. This is confirmed by the work of Rosa on vegetables presented in the accompanying paper. There is every probability, therefore, that the hardiness of our fruit plants may be increased by proper procedures of orchard management. Space is not available in this abstract to enter into details but an interesting problem present itself as to the methods which can be used to increase the pentosan content of plant tissues. The whole subject of orchard procedures at the critical time of year is open for re-investigation from this new point of view.

It must not be forgotten, however, that much work yet remains to be done. The specific pentosans responsible for the water-holding capacity of different plant tissues must be determined. The effect of other factors such as acidity, hydrogen ion concentration, various salt mixtures (cf. Maximou), etc., on the water-holding capacity of these pentosans, must be studied. Finally, the water-holding capacity of plant tissues must not be considered the only factor in hardiness, even though it should prove to be very important, and one explaining many of the observed facts relating to winter injury.

Pentosan Content in Relation to Hardiness of Vegetable Plants

By J. T. Rosa, Jr., *University of Missouri, Columbia, Mo.*

UNDOUBTEDLY, several factors may be connected with killing of plants by cold, but from the work of several investigators, it appears that water-loss by the cells during freezing is most generally the limiting factor which is primarily responsible for death. It would be reasonable to suppose that anything which opposes water-loss by the protoplasm during freezing would tend to increase the ability of the plant to survive.

In a report to this Society at the last annual meeting, it was shown that hardiness to cold could be brought about in vegetable plants by any one of several treatments which checked vegetative growth, including partial withholding of water and exposure to low temperature in the cold frame.

The work of Spoehr on cacti shows that under conditions of stress, especially drouth, there is a very marked increase of pentosans. The enormous water holding power of substances of this type is well known. To quote from McDougal and Spoehr, "Analyses of desert plants show that in cells undergoing water depletion, polysaccharides are reduced to pentosans of which the mucilages are largely composed. Aridity * * * causes changes in the cell by which the amount of water it may hold is greatly increased. This gives the cell mass a permanent water storage, as the pentosans are not reconvertable into the polysaccharides." Again, McDougal states that "protoplasm of plants consists of a comparatively inert base of pentosans * * * in colloidal combinations with proteins, amino acids, lipins and salts, to form a complex mass varying from liquid condition to that of an elastic gel." In view of the findings of McDougal and Spoehr in the case of cacti, it seemed logical to look to the pentosan content of hardened plants for an explanation of their resistance to cold.

This object has been attacked along three lines during the past year. Pentosan determinations have been made on plants of cabbage, cauliflower, kale, leaf lettuce, celery, and tomato. One series consisted of plants grown in the greenhouse, and "hardened off"

TABLE I

Per cent Pentosans in Vegetable Plants—On Fresh Weight Basis.

	Cabbage	Leaf Lettuce	Cauliflower	Tomato
(a) Moisture Series				
A1. Wet-grown plants in greenhouse, tender, ...	.215	.106	....	....
A2. Medium moisture in greenhouse, medium hardy, ...	.320	....	....	....
A3. Dry-grown plants in greenhouse, hardy, ...	.423	.402	....	....
A4. Partially wilted for two weeks in greenhouse, hardy, ...	.412	....	....	....
(b) Coldframe Series				
E4. Tender greenhouse plants, ...	.207	.126	.191	.091
E3. Hardened in coldframe, 1 week, ...	.413	....	....	.277
E2. Hardened in coldframe, 2 weeks, ...	.530	.230	.403	.226
E1. Hardened in coldframe, 3 weeks, ...	.604	....	....	.362

in a coldframe in the usual manner, these hardened plants being then compared to plants of the same age kept in a warm greenhouse under favorable growing conditions. Another series consisted of plants grown in the greenhouse under conditions as nearly uniform as possible, except the moisture content of the soil, which was regulated so as to give high, medium, and low water supply to the plants. The third series was derived from young vegetable plants growing in the open garden, in which the changes were studied from early fall until the plants were killed by heavy freezes in November.

In Table I each figure represents the average of from two to six analyses. It is seen that the percentage of pentosan in the fresh plant-tissues shows a regular increase, both in the plants hardened by withhholding moisture, and in plants hardened by exposure to low temperatures in a coldframe. Summarizing the analyses given in Table I, it is seen that the pentosan content varies as follows:

Cabbage, from	.207 to .604	per cent.
Cauliflower	.191 to .403	" "
Leaf Lettuce	.106 to .402	" "
Tomato	.091 to .362	" "

The range of pentosan content in these species of vegetables falls in the same order as they would usually be placed by the gardener, from the standpoint of hardiness.

TABLE II

Per Cent Pentosans, Garden Plants, Fall 1920. On Fresh Weight Basis.

Date	Kale	Cabbage	Celery
October 7th	.152	.181	.293
October 20th	.259	.155	.501
November 3d	.522	.305	.538
November 10th ...	......	.493	......
November 18th ...	.593	......	......

In Table II, it is seen that there is a fairly constant increase in the pentosan content in these vegetables from early fall until the plants were killed by cold in November. The outdoor temperatures declined steadily during this time, light frosts being followed by freezes until the plants were killed. Otherwise, growing conditions were favorable.

One of the means we have used to harden plants is partial withholding of water. McCool and Miller, working at the Michigan Experiment Station, showed that plants grown on soils of low moisture content contained less "easily freezable" (free) water than plants grown on soils of high moisture content. Their work thus affords direct corrboration of our theory, that hardened plants

contain a greater proportion of "absorbed" water in colloidal combination with the pentosans of the protoplasm, which is not frozen upon exposure to moderate freezing temperatures. The same conditions must be true of plants hardened by exposure to low temperature as well as other treatments which check growth, and which have been found to increase the cold resistance of plants. The protoplasm of hardened plants apparently possesses a greater water-holding power than non-hardened plants, which may be accounted for by the fact that hardened plants have been found to contain increased amounts of pentosans, roughly proportional to the degree of hardiness.

Cryoscopic determinations have been used by numerous investigators as an index of the hardiness of plants. The greater depression of the freezing point of the sap found in hardened plants is to be expected, in the light of our theory of hardiness. If in hardened plants a greater proportion of the water content exists in the absorbed colloidal condition, the sap solutes must be held in a more concentrated solution by the lessened amount of free water, as a large part of the plants' moisture supply is withdrawn by the protoplasmic colloids. It was found by McCool and Miller that the amount of "easily freezable" water in plants decreased as the depression of the freezing point increased.

If the investigations now under way confirm our theory as to the nature of the hardening process in plants, it appears that the question of cold resistance in vegetables, in winter cereals, in fruits, and in evergreen plants, may be attacked from a new angle, with especial reference to the influence of cultural treatments upon the ability of the plant to withstand cold.

The Hardiness Problem

By M. J. Dorsey and J. W. Bushnell, *University Farm, St. Paul, Minn.*

THE general question of hardiness has been given careful attention by several investigators in the last two decades. Reports have appeared presenting the results of the studies upon many phases of the problem. Since horticulturists are so generally confronted with injury to fruits by low temperatures, it appeared to the writers that a brief review of the outstanding research in this field, together with a suggestion of what appear to be the most fruitful points of attack, might be of some service at this stage of the investigation. Throughout this paper the subject will be treated primarily from the standpoint of injury during winter.

In regions where low temperatures occur during the dormant period, a relatively definite degree of hardiness is necessary in all

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fruits. Therefore, while hardiness is in many respects a relative matter, for any region it becomes fairly specific for a given variety. When the extreme or test winters are considered, it becomes apparent that the fruit industry in many regions is based upon varieties which prove to be little more than semi-hardy.

The Extent of Winter Injury: In the Northwest the test winters have come at quite regular intervals and are generally considered to be 1872-73, 1884-85, 1898-99 and 1917-18. Macoun ('18) states that in the eastern provinces of Ontario and Quebec they were 1858-59, 1876-77, 1884-85, 1895-96, 1898-99, 1903-04, and 1917-18. It will be seen that these do not correspond exactly with the test winters in the Northwest.

An idea of the extent of injury these years may be obtained from the following statements. As a result of the winter of 1872-73, Patten says "We have lost thousands of apple trees of our hardiest varieties by the tender seedling roots under them freezing out." ('00, p. 179). "The winter of 1884-85 and the remarkable drouth of 1887, destroyed all the apple orchards in Iowa except in a few localities." (Speer, '88.) In the Northwest the winter of 1898-99 was particularly severe. Hansen ('99) states that this winter "wrought widespread destruction in northwestern nurseries and young orchards." Goff ('00) summarizes the injury in the northern states from reports received from widely separated sources. These showed that damage occurred to both tops and roots, especially to roots where there was little or no snow protection. Many trees died after starting growth in the spring. Morse ('09) quotes from a survey by the Commissioner of Agriculture to show the extent of winter killing in Maine in 1906-07. This survey included 950 orchards and 443,183 trees, 24,613 of which were killed outright. Approximately as many more (varieties not specified) were injured. This winter appears to have been particularly severe in Maine, as it is not mentioned in test winters listed above for the Northwest or eastern provinces of Canada.

The winter of 1917-18 was also exceptional in the amount of damage to fruit trees and in the large area over which the damage occurred. Macoun ('18) reports that in the Experimental Farm orchards at Ottawa 360 apple trees, including 200 varieties, were killed by the winter of 1917-18. Chandler ('18) and Blake ('18) report severe injury to tree fruits in many sections of New York and New Jersey. Farther west the observations of Paddock ('18), Oskamp ('18), and Gunderson ('18) show that there was unusual injury to the peach in Ohio, Indiana, and Illinois respectively. Farther north the reports of Moore ('18) for Wisconsin and of Dorsey ('18) for Minnesota, show that the season of 1917-18 was severe in the Northwest. Farther west, in Montana, there was extensive injury to fruit trees even when irrigated. Still farther west and north, the killing was also unusually severe to tree fruits at the trial stations of the prairie provinces of western Canada, at Lethbridge, and Locombe in Alberta, at Indian Head in Saskatchewan, and at Brandon in Winnipeg, and Morden in Manitoba.

These statements show that injury to dormant fruit trees by exceptional winters is of wide occurrence. Such winters may be expected to occur again and plantings should be made with this in mind. Statements in the literature show that the injury may be more or less local in extent, as in the case of the apple in Maine in 1906-07, or more general as in 1917-18. Some seasons one fruit may be injured more than another and still other seasons may be characterized by root killing or by top killing. While in the colder sections like Minnesota there is considerable injury each year to the tenderer varieties, the greatest injury to the fruit industry does not necessarily occur in the colder regions. This is borne out by the experience of citrus growers in California and Florida. Letting this brief statement as to the extent of injury suffice to show the importance of the problem, let us note what types of injury have been reported.

Types of Injury: Bailey ('96) found in *Prunus domestica* that the spurs were sometimes killed and also that the shoots were killed back. A loosening of the bark from the tree has been noted by Taft ('99), Morse ('09) and Grossenbacher ('12 and '17). Root killing has been discussed in considerable detail by Craig ('96), Goff ('99), and Hansen ('99). Emerson ('03) found discoloration in the wood and bark and killing back of the limbs in the peach. Waite ('04) speaks of bark and wood killing, and tip or twig killing. Eustace ('05) classified winter injury under three heads,—wood, trunk, and bark injury, later including bud killing. Selby ('08) found cracking of the bark and a browning of the inner bark. Macoun ('09) classified winter injury more in detail under the headings root killing, bark splitting, sunscald, crotch injury, killing back, trunk injury, body injury, killing of dormant buds and killing of swollen buds. Chandler ('13) discusses crotch injury, crown rot, sunscald, killing of the trunk, tip, and branch, and root injury. Frost cracks have been studied by Muller-Thurgau ('86), Chandler ('13), and Grossenbacher ('12) and ('17). The term "sun scorch" is used by Grossenbacher ('17) in describing injury on the southern side of branches or trunk. In Minnesota the cracking of the trunks is very common, both in the orchard and forest. It has been observed several times that winter injury to peach and plum trees may not take place below the snow line (Taft, '99; Eustace, '05; and Waite, '04). Many investigators have noted winter injury to fruit buds, and the percentage of the flower buds killed in the dormant winter fruit buds has been used as a basis for classifying varieties as to hardiness (Craig, '00; Chandler, '07 and '13; Whipple, '12, and others). Moore ('18) says that in Wisconsin the most common type of injury is "southwest injury," so-called because the injured areas occur primarily on that side of the trunk and main branches. Mix ('16) concludes after an extensive series of artificial freezing tests that sunscald is caused by direct freezing to death of the tissue. The greater hardiness of the cambium compared with the wood or bark in dormant trees has been frequently noted (Chandler, '18, and others). This condition accounts for recovery in the peach and plum after

severe injury. Frequent mention has also been made of instances where killing may occur in the top and not in the root, and vice versa, although both may be injured the same season. In a histological study of crown-rot Grossenbacher ('17, p. 497) found "evidence that high tension, and extreme ruptures accompany some at least of the more severe bark injuries," and in an earlier publication ('12, p. 46) he states that the "initial injuries which eventually result in crown-rot and canker occur in winter." Paddock ('18) mentions an instance in the peach in which "quantities of fruit buds survived the winter" on trees which failed to send forth leaves in the spring. This condition has been observed in a few instances in the plum in Minnesota.

It will be evident from the foregoing that careful observations have been made of the injury to fruit trees by low temperatures of winter. Injury has been found to occur in practically every part of the tree. The fact that it is so variable from season to season and also in different forms, has no doubt been largely responsible for the popular impression among many growers that winter injury can largely be controlled by cultural methods. This phase of the problem deserves careful consideration because wrong conclusions as to cultural practice may have far reaching consequences. Therefore, it will be interesting to know how far winter injury may be modified or controlled by cultural methods.

Horticultural Practice in Relation to Hardiness: The use of hardy roots, trunks, and tops has from the first been recognized as one of the most effective means of avoiding winter injury. The principle involved is relatively simple in that there is merely a substitution of selected stock for that part of the tree most susceptible to injury. The selection of the proper stock can only settle the question of hardiness as far as the stock goes and it is not uncommon especially in the apple (Dorsey, '18) to find the tender grafts killing back to the hardy stock. It will be safe, therefore, to assume that fundamentally the stock does not increase the hardiness of the scion except in-so-far as maturity and nutrition may have a bearing upon hardiness.

Pruning has a marked influence upon winter injury. Excessive pruning results in a vigorous late maturing and hence a tender growth. Severe dehorning has been found to be poor practice in the peach, by Waite ('04), Chandler ('07 and '08), Oskamp ('18), and others. Chandler ('18) found peach trees which were injured by winter "recovered much better when fertilized early in the spring with about four pounds of nitrate of soda to the mature tree." On the other hand, the fruit buds on the vigorous growths following heavy pruning escaped injury because they remained dormant later in the spring (Chandler, '07 and '08). Experience favors short trunks, well placed limbs in the frame work in which there are no long exposed parts, as one of the most effective means of avoiding sunscald. In relation to hardiness the primary consideration is to follow that system of pruning which induces early maturity, a moderate growth, and a compact low-headed tree.

Cultivation in relation to hardiness will be discussed from the

standpoint of nutrition, soil moisture, and maturity. Excessive nourishment, like over pruning, produces a late succulent tender growth. At the other extreme, deficient nutrition renders trees less hardy. This was noted by Green and Ballou ('04), who record that after the severe freeze in Ohio of 1903-04, "trees and orchards of low vitality, generally speaking, suffered most severely." Chandler ('07, '08) shows that there is an appreciable difference between the hardiness of peach buds on the thinned and unthinned sides of a tree. Macoun ('18) found that eight Wealthy trees in the experimental orchards at Ottawa bore good crops of fruit in 1917 and six either a light crop or none at all. The latter only "all came through in good condition." Similarly, Chandler ('18) observed in New York that "in numerous orchards throughout the state trees that bore a heavy crop during 1917 were killed entirely or injured very badly, while adjacent trees of the same variety and growing under the same conditions, but having their off year in 1917 were uninjured." Other instances could be cited which show a similar relation between hardiness and fruit production and exhaustion. The influence of exhaustion and an unbalanced or insufficient food supply upon hardiness, is in many cases pronounced, and results from controlled experiments on this phase of the problem will be looked forward to with interest.

Fruit growers in the Northwest have observed many times in the last fifty years that severe injury, especially to the roots, follows dry fall weather. In fact, a dry fall followed by an "open winter" is generally recognized as bringing about the conditions under which greatest root injury take place. Hansen ('99) recommended watering in the fall before the ground freezes as a preventive measure against killing, in the dry soils in South Dakota. Using the Burbank plum as an index, Chandler ('18) found more severe injury during winters of higher temperatures which were preceded by dry summers than during the severe winter of 1917-18. In the more arid regions of the Dakotas, Pfaender ('18) notes that shelter belt trees on the outside of plots surrounded by clean cultivation, were injured more than trees on the interior. He correlates the killing with greater moisture and hence later growth. An experiment of Emerson ('03) on the relation of soil moisture to killing is sufficiently specific to warrant mention. In this experiment seven boxes, two feet square and 18 inches deep, were filled with "common loam soil of varied water content." In each box 25 apple trees and 10 Mahaleb cherry seedlings were planted. In December, six boxes were placed out in the open in an exposed place, one box being reserved in "a cool dry cave" as a check. None of the cherry roots were injured enough to prevent their growth. In the case of the apples "in general the roots from the dryer soils showed more discoloration than those from the moister soils." None of the roots were killed at the tips, and the line of demarkation between the dead and live parts of a root was usually well defined. In a few cases the "dead part of the root extended only an inch below the surface of the soil, but in most cases it ran down two to four inches and in some the roots were

dead as much as seven inches." Emerson points out that "it is quite probable that one cause of great injury in rather dry soil is alternate freezing and thawing," since this is more pronounced in dry soil and is partly prevented by the straw mulch.

The experience of fruit growers in the colder regions of the United States and Canada, indicates that the chief influence of nutrition and soil moisture upon hardiness comes in their relation to hardening, or maturity of the wood. A system of cultivation must, therefore, provide adequate nourishment, but at the same time prevent a late vigorous growth. Young trees, on account of late growth and vigor, are often killed more than older ones (Eustace, '05, and Waugh and Green '05), while older trees are often reduced in hardiness by over production. Cultivated orchards are sometimes injured more than neglected ones (Emerson, '03). Green and Ballou report an instance in Ohio in which one section of an orchard under clean cultivation for eighteen years was injured more by the winter of 1903-04 than the other of the same age which had had a cover crop of crimson clover each year.

Closely related to cultivation, the use of hardy stocks, and pruning in its bearing upon hardiness, is the general question of protection. This may take the form of windbreaks, covering of soil, straw, or other materials, and protecting the soil with mulches or cover crops. Windbreaks have their chief influence during dormancy in reducing drying out by winds, and if correctly placed, in preventing injury from deep snow drifts. During the growing season their chief value comes from the protection afforded to blossoms and fruit. The influence of windbreaks upon air drainage is a matter of less consideration on the prairies than in hilly or rolling land where there is less wind and where pockets and low places occur. Covering plants with soil is at best an expensive process and while feasible in a limited way with some fruits, such as the brambles and grapes, it is at best only a method of dodging the hardiness question and a tacit admission that a plant is out of its range of adaptation.

Orchard cover crops and mulches have their chief value in the influence upon soil temperatures, either directly or by holding snow. Delwiche and Moore ('07) noted in testing different cover crops that in general they lessened the depth of freezing "at least one half." Green and Ballou ('04) found that in Ohio a soil that froze eight inches under a cover crop froze eighteen with no protection. Peach trees made a "healthy, unform growth" in sod row, but were practically killed in bare soil. Likewise Emerson ('03) found that in Nebraska the frost line was 24 inches deep in the bare soil and only 15 inches deep under a cover crop. Goff ('99) observed that the protection afforded by snow prevented root killing in many regions in the Northwest during the severe winter of 1898-99. On the other hand, while some cover crops bring about earlier maturity and hence greater hardiness, as noted above, the chief danger in their use, especially in dryer regions, lies in the reduction of soil moisture.

From this discussion it will be evident that there are some

widely recognized cultural practices which favor winter injury, or which tend to prevent it. When a variety is on the border between the zone in which it is hardy and that in which it is half-hardy or tender, the cultural treatment alone may be such as to determine success or failure. It is important to recognize, however, in regions with a severe climate, that all that can be done by growers in the way of manipulating cultural methods may not be sufficient to prevent injury, especially during test winters.

The Rest Period: One phase of hardiness closely related to cultural practice, which may be covered by the general term "rest period," has been given considerable attention. The period when plants do not grow is characterized by a minimum or perhaps by a complete cessation of cell activity. Investigations at the Missouri Agricultural Experiment Station and elsewhere have brought out many outstanding facts regarding the rest period. About 300 species of woody plants were found to have a definite rest. The time when the rest period began after the season of active growth and the length of time it endured with reference to the winter season, were found to be individual characteristics of each species or variety. The intensity of the rest was also found to be a species characteristic. Some of the forms were so deeply dormant that they could not be induced to start growth until well toward the end of the winter season, while others would start immediately upon being subjected to growing temperatures in the greenhouse. The time, length, and intensity of rest were, therefore, all found to be variable when a large number of forms were considered

Likewise factors such as drying and low temperatures induce plants to enter rest while others like anesthetics, and growing temperatures will bring about a break in the rest, in many forms especially when the end of the rest period is approached. The fact that the great majority of species indigenous to temperate climates, as well as many varieties of fruits, enter a profound rest for only a short time in early winter, makes it necessary to modify cultural practices accordingly. In the peach, for instance, in Missouri, the best cultural practice appears to be to bring on maturity late, so that the rest period is extended through the warm spells in winter and early spring. On the other hand, in Minnesota where injury results from low temperatures when trees are to all appearance dormant, and where warm periods seldom if ever bring about any appreciable growth during dormancy, it is necessary for fruit trees to be fully mature before winter sets in and to remain dormant while killing temperatures are prevalent.

The work of Winkler ('13), Harvey ('18), and Strausbaugh clearly demonstrates the relation between killing and dormancy. In woody plants Winkler found that the hardiness of dormant twigs was not constant throughout the winter, but that killing temperatures were much lower preceding warm spells than immediately following. Working with succulent plants, Harvey found that a five days' exposure of cabbage to 3° C. hardened the tissues sufficiently that a 30-minute exposure to -3° C. produced no injury, although the leaves were frozen stiff. The cabbage plant

was found to acquire hardiness rapidly by exposures to low temperatures and also to lose it rapidly when exposed to high temperatures. Working with the plum, Strausbaugh (results unpublished) showed that coincident with the break in the rest period in mid-winter as indicated by anthesis, the moisture retaining power of twigs and buds in the semi-hardy varieties Stella and Tonka, was lessened, while in Assiniboine, which was still dormant, it remained constant. It is significant that killing in flower buds of the plum follows the break in the winter rest.

If a plant is more susceptible to injury after the rest is broken, the question arises as to whether even a semi-hardy variety, as the Burbank plum in Minnesota, would be killed if subjected to what are ordinarily killing temperatures while still in deep dormancy. The evidence on this point indicates that there is a killing temperature for all species of woody plants even while in deep dormancy, but that for some it is seldom if ever reached. To summarize briefly, the investigations of the rest period to date show an intimate relationship between dormancy and hardiness and also furnish an accurate guide to cultural methods.

Adaptation and Hardiness from the Genetic Viewpoint: In both the extent and the types of injury it was shown that strictly speaking many varieties of fruits are grown extensively in regions where the climate is too severe for them. Experiments with plants which have been grown north or south of the place of their nativity, bring out fundamental differences in seasonal responses between seedlings of a species and of a variety or clone.

Emerson ('06) grew walnut seedlings at Lincoln, Nebraska, from seed obtained from South Dakota, Ohio, and Oklahoma. The northern seedlings matured earlier and were hardier than those of southern origin. In these experiments Emerson's classification shows a definite relation between maturity and hardiness. Whitten (Dorsey '18 a) made a similar comparison of the hardiness of seedlings of certain species of trees by growing seed obtained from the northern and southern part of their natural distribution. The seed from the northern range came up first "generally" and produced trees which made at first far less growth than those from the central point of the range near the latitude of the experiment. The northern trees also had a much shorter growing period, starting later in the spring and maturing their leaves earlier in the fall. Trees from seed gathered at the extreme southern range had a relatively brief rest period, pushing into growth with the very first warm days of late winter or early spring and "shedding their leaves very much later in the fall."

In these two experiments seedlings were grown near a midpoint in the distribution of the species. Evidence is at hand from an experiment carried out at Itasca Park by J. P. Wentling, of the Department of Forestry of the University of Minnesota, which shows clearly what happens when seedlings from a southern part of the range are grown at the northern extreme. In this experiment native seeds of *Quercus rubra* were obtained from Clarion County, Pennsylvania, from University Farm, and from trees

growing at Itasca Park, near the site of the experiment. All seedlings made a good growth the first season after planting. During the winter those from Pennsylvania were completely killed out, even the roots; those from University Farm were killed to the snow line; while seedlings from seed gathered at Itasca Park were uninjured. A similar response to early frosts in the fall was shown by grape cuttings of *Vitis vulpina* (Dorsey, '18 a) when the leaves on cuttings from Missouri and Arkansas were killed, while those from Ames, Iowa, University Farm, Itasca Park, and the Lake of the Woods in Minnesota, were uninjured. These cuttings have subsequently been planted in the test plots at the Fruit Breeding Farm, and the vines from Arkansas and Missouri bloom from four to six days earlier than those from Minnesota.

The greater hardiness of northern grown seed of trees such as the box elder, elm, and maple, which are grown extensively for windbreaks, has also been demonstrated many times by plantings in the north central states and in the prairie provinces of Canada.

With these illustrations in mind, dealing with seedlings taken from the northern and southern range of a species, it will be of interest to note the relative hardiness of varieties grown in southern and northern locations. Such a list could be extensive, but a few instances will illustrate the principle involved.

In the raspberry, such of the standard varieties as Louden, Marlboro, Columbia, and Munger, unless covered, are killed to the snow line during an average winter in north central Minnesota, and are killed to the ground by more severe winters. The same results are observed with Snyder and Ancient Briton among the blackberries, and Premo, Austin, and Lucretia among the dewberries. It is interesting to note in view of the killing found in these varieties that native forms of the red and black raspberry, dewberry, and blackberry, are found in the northern part of Minnesota. In the plum, Cheney, a variety of *Prunus nigra*, which originated in Vernon County, Wisconsin, browned in the wood at Indian Head, Saskatchewan. Some of the other varieties, among them Sapa, Opata, Compass, and Terry, which are generally hardy in the southern half of Minnesota, winterkill in some parts of Manitoba even when protected by windbreaks. On the other hand, Sapa and Opata are hardier in the more arid climate of western South Dakota than they are in Minnesota. As in the case of the plum, when Oldenburg, Hibernal, Wealthy, and Whitney varieties of the apple which are placed in the hardy list in Minnesota, are grown in Manitoba, there is considerable injury to the wood by the more severe winters.

The seasonal response of individual plants of a variety when growing in the North and in the South, is shown in part by the time of bloom. Waugh ('96-7) collected data which show as much as 73 days difference between the blooming date of the Downing plum in Ontario and Texas. That there is no permanent adjustment, however, in the length of the growing season in a variety as in the species when different individuals are grown a considerable distance north or south of the place of origin, is brought out by Whit-

ten (Dorsey, '18 a). Buds of Elberta and Old Mixon Free were obtained from different points between Michigan and Texas and grown at Columbia, Missouri. Whitten says: "We have never been able to detect any differences in hardiness, in phenology, or in habit of growth" of these introduced trees.

Instances are not numerous in which a single limiting factor has been found to determine the northward distribution of a species, but Shrieve ('11) found "that the greatest number of consecutive hours of freezing is the most important climatic datum" in determining the nortward range of the giant cactus, *Carnegia gigantea*. It was shown experimentally that continuous freezing without thawing could not be endured without injury by this species for more than twenty-four hours. Salmon ('17 a) shows that "the isotherm of 10° F., daily minimum coincides remarkably well" with the southern limit of spring wheat and the northern limit of winter wheat in the United States and Canada.

These illustrations suggest that one factor of the environment, temperature, may form an effective barrier to the advance of a species northward, as in the case of cactus and the red oak, and that it may also draw a relatively sharp line between the zones of successful cultivation of winter and spring wheat. The instances given of the killing of many varieties of fruit when planted too far north, illustrate the effectiveness of low winter temperatures in preventing the northward planting of certain clones.

It is unnecessary here, even if they were known, to enumerate all the possible factors which may operate in limiting the northward distribution of a variety or species, but in the ability to withstand low temperatures of winter, a single characteristic may be taken to illustrate the principle involved from the genetic point of view.

Suppose in the first case that a species is homozygous for all of those factors which enable the different individuals composing it to withstand low temperatures during dormancy in a given area. When its distribution by any means is extended northward, a given set of conditions during winter would result in the same degree of injury to all individuals, and if all were killed over a considerable area, further advances northward would stop, until further introduction of the same kind again took place. The process of killing off may be repeated by the severest winters, but always with the same result. In the second case, suppose that the species is heterozygous for those factors which enable it to withstand the low winter temperatures. In this case when plants become distributed northward, by any means, from the original habitat, some may be killed by the more severe winters, others injured, while still others may endure the conditions which prevail without injury. Reproduction would take place from the hardiest, and the process of elimination by winter injury would continue until the plants which could persist on the northward border of the range would differ as to hardiness from those farther south, which may have been selected out by the reverse conditions. This is the status which appears to have been brought about in the oak, walnut, and grape.

Any other character, such as season of maturity or hardiness of the winter fruit bud, may have been selected for the illustration, but in the end the result would be the same, namely, isolating by winter killing at the northern range of the species, individuals which are hardier than those native farther south. It may be safely assumed, since the species is heterozygous, that the plants of the species in the North are genetically different from those farther South in that only those possesssing the factors for hardiness, have survived.

From this conception of adaptation it is apparent that a fundamental distinction can be made between a species and a horticultural variety with reference to adaptive adjustments. Winter killing, cultural methods, and differences in the rest period all take their place in relation to fundamental survival differences. It now remains to be seen what physiological investigations have shown as to the nature of hardiness and of the internal changes which occur as a result of killing.

The Physiological Phase of Hardiness: Fortunately a number of excellent reviews of the physiological investigations have appeared in recent literature (Chandler '13, Mix '16, Grossenbacher '17, Salmon '17, and Harvey '18). Reference should be made to these for a comprehensive treatment of the past work.

Taken together with the studies of the rest period noted above, the physiological investigations go far toward showing the way in which dormant plants are affected by low temperatures. In this connection reference will be made briefly to the later work in order to show the trend of the investigations at present. The studies of freezing in succulent plants will not be overlooked here since it appears that killing in succulent tissue, and in dormant woody tissues, may have much in common and that much can be learned of the latter from the former.

Harvey ('18) has extended the investigations of Gorke ('06), Schaffnit ('10), and Chandler ('13), upon the relation of changes in the proteins to killing. His results show that upon hardening "the proteins change to forms which are less easily precipitated." During the formation of ice there is an increase in acidity sufficient to precipitate the proteins of non-hardened cabbage, but in hardened plants the proteins endure the same degree of acidity without injury. Chandler ('13), however, in analyzing frozen and unfrozen cabbage plants both hardened and non-hardened, was unable to detect any appreciable precipitation of proteins and consequently held to the view that "killing from cold is more likely a mechanical injury due to the withdrawal of water from the protoplasmic membrane than an injury resulting from a precipitation of proteins."

Until the relation of proteins to frost injury was determined, it was difficult to account for the increased hardiness of plants grown in strong salt solutions, or injected with salt solutions. If the precipitation of the proteins was due to the increased concentration of the salts of the cell sap, it would be expected that any increase in the salt content would increase the injury. It was

shown by Maximow ('12 and '14) that sections of plants soaked in salt solutions were actually increased in hardiness unless the solutions were excessively toxic. Under these conditions increased concentration of the salts in the cell sap was accompanied by an increase in osmotic pressure resulting in a physiological drying of the protoplasm. Harvey states that a similar increase in the concentration of the cell sap accompanies a condition of greater resistance to freezing from any of those treatments checking growth, such as watering with NaCl, growing the plants in dry soil, or exposing them to cool temperatures. This increase in the concentration of the cell sap apparently is favorable to those changes in the proteins by which they acquire hardiness.

The drying which occurs while the plant is frozen is very probably a factor of injury, particularly in regions with high winds and low humidity. The injury to trees under such conditions is commonly killing back of the twigs and injury to the buds. As has been suggested by Harvey's work, drying of the buds and twigs may result in an effect on the tissues very similar to that of extreme temperatures.

The splitting of the trunk and the injuries to the bark resulting from high tensions during low temperatures, have been emphasized by Sorauer ('06), Grossenbacher ('17), and others. This type of injury is due to physical tension and is distinct from those types due to the disturbances in the cell content.

Attempts to find correlations of plant characters with hardiness of seedlings and new introductions without waiting for a test winter, have generally led to the conclusion that the only reliable index of hardiness is early maturity and a long rest period. These studies are mentioned here for it would be valuable to know that morphological or physical differences could be correlated with hardiness. Determinations of sap density have been made by Chandler ('13 and '14), Ohlwieler ('12), and others, but aside from the increased concentration of the sap as the plant hardened and dried, no correlations were discovered. The recent work of Salmon and Fleming ('18) with hardiness in cereals, showed that there was no apparent relation between the density of the extracted sap of winter rye, wheat, emmer, barley and oats, and their ability to resist winter killing.

Beach and Allen ('15) attempted to find physical and morphological characters of the plant that might be correlated with hardiness in the apple. After studying the hardness and specific gravity of the wood, the moisture content in winter and summer, the structure of the bark, the starch content of the wood, and the shape of lower parts of the trees, they conclude that "from the practical viewpoint as yet it is impossible to name any one test by which the degree of constitutional hardiness of a seedling apple may be foretold." However, they agree with the common observations that early maturity of the tree is essential to hardiness, but point out that not all early maturing varieties are hardy.

Thus far in this discussion the physiology of hardiness of the plant as a whole has been considered, but a consideration of the

numerous types of injury and the results of the tree show that all the parts are not equally susceptible to winter injury. The roots are very much more easily injured than any of the above ground parts; the deeper and smaller roots being the most tender.

It will be clear from the above that while the plant as a whole is subjected to a given set of conditions it does not react as a unit. Roots and top have a different killing point and some tissues of the tree are more subject to injury than others. These are well illustrated by the type of injury mentioned above. Again, differences in the rest period have far-reaching consequences in relation to winter injury. When the internal changes which initiate a break in the rest and which appear to be influenced so directly by environment, are well understood, one of the greatest advances in the hardiness problem will have been made. The changes which take place in the proteins upon hardening have great promise in this direction but it yet remains to be seen whether these are the initial and only changes concerned. Finally when hardiness is studied in a heterozygous progeny of parents differing in hardiness, varying degrees of cold resistance are found. Here then is suitable material for all points of attack and no final solution can be considered near which does not set forth clearly the fundamental difference between the parents, between the progeny, and between parents and progeny.

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The Seed Content and the Position of the Fruit as Factors Influencing Stippen in Apples

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THE physiological disease of apples known as bitter pit or stippen developed to an unusual extent during the past season on the fruit of certain trees in the experiment station orchard at Ithaca, N. Y. It was especially prevalent on apples of mature Baldwin trees growing in a sod orchard. The set of fruit on these trees, as in most other varieties, was very good, many spurs holding more than one fruit. Apples on some spurs were badly pitted, while those on adjoining spurs were practically free from the disease. Frequently one apple of a cluster showed stippen, while the remainder were entirely normal. These conditions suggested the possibility of a relationship between the occurrence of bitter pit and the location or the character of the fruit bearing spur, the position of the apple on the cluster base, and the seed content of the individual fruit. No reference to such relationships have been found in the literature.

Methods

The methods used in this preliminary study were very simple. Spurs holding two or more fruits of which at least one was affected with stippen were collected from several of the Baldwin trees referred to above. Care was taken to avoid specimens with stigmonose or fruit spot, but, no doubt, many apples were included that showed a form of drouthspot which produced no exudate and which so closely resembled bitter pit as to be practically undistinguishable. Notes* regarding the amount and distribution of the pits or spots, to the position of the fruit on the cluster base, the size of the apple, and the maturity and seed content of each fruit, were recorded. In certain cases the location of the spurs holding fruit affected with the disease was also noted. Some of the apples were kept in the laboratory to study the subsequent development of bitter pit. Fruits from common storage were also available for study.

Results

An analysis of the data thus obtained indicates the existence of relationships between the occurrence of stippen, and the factors discussed under the following heads:

1. The position of the fruit on the cluster base.

Apples developed from central flowers were borne on the same spur with those derived from lateral flowers in 150 of the cases obtained for study. In all these cases the lateral fruit showed

*(See bibliography at end of paper.)

bitter pit, while 70 per cent of the central fruits were entirely free from the disease. In the remaining cases, the disease occurred in both central and lateral fruits, but the lateral apple showed most pits in 39 of the 45 clusters. These observations and others indicate plainly that stippen which appeared before harvesting, occurred most frequently in lateral fruits of a cluster. A similar relationship between the occurrence of bitter pit and the position of the fruit in the cluster was also observed in the varieties Tompkins King, Northern Spy, Ben Davis and Grimes.

Central fruits borne singly often show stippen, while central fruits in clusters on the same branch are normal. This suggests that possibly the lateral fruit of a cluster protects the central fruit against Baldwin spot. In the few cases where it was possible to compare central fruits borne singly with lateral fruits borne singly, the former seemed more resistant to bitter pit.

2. The location of the fruit spur on the branch.

When the clusters showing apples with bitter pit were collected, it soon became apparent that the spurs with most disease were generally found in the basal portion of the branch. This relationship is expressed in the records of the distribution of spurs holding apples with and without bitter pit in 10 representative branches. These branches were about an inch in diameter at the point of origin, and each had from 10 to 20 fruit bearing spurs. That half of the total number of spurs found near the end of a given branch were designated as terminal spurs; the remaining half were classified as basal clusters. The data are given in the following table:

TABLE I

Location of Spurs and Bitter Pit

Fruits considered	Basal Spurs		Terminal Spurs	
	Number of apples	Percentage with bitter pit	Number of apples	Percentage with bitter pit
All	193	67.4	179	40.8
Lateral only	136	80.9	111	50.5
Central only	57	35.0	68	25.0

In all individual cases the same tendency toward more disease on the basal spurs was clearly shown. The spurs originating in the upper portion of the branch would generally be younger and they would probably have better chances of obtaining water and nutrients.

3. Nature of the bearing wood.

The amount of fruit affected with stippen varied considerably with different branches. In general, the apples on wood that originated from the upper side of healthy limbs, and which made a fair vegetative growth were relatively free from bitter pit, as com-

pared with fruit on branches making less vegetative growth, such as those which had been ringed early in the season, or which arose from the under side of limbs, or from weak wood. Table 2 gives data from a number of branches taken from trees which showed much stippen.

TABLE II

Bitter Pit and Vigor of Wood

Fruits considered	Strong Branches		Weak Branches	
	Number of apples	Percentage with bitter pit	Number of apples	Percentage with bitter pit
All	206	32.0	195	76.1
Lateral only	123	39.0	146	83.5
Central only	83	21.8	49	51.0

It is evident from these data that apples on weak wood are more subject to bitter-pit than those on strong branches. The fact that central fruits are less susceptible than lateral apples is again shown.

In several cases sodium nitrate was applied to one side of Baldwin trees in sod, while the remaining portion served as a check. Fruit on limbs corresponding to the side receiving fertilizer showed less Baldwin spot than apples on limbs which did not have the nitrate. The disease was less prevalent on mature Baldwin trees in partially cultivated land than on similar trees growing in sod. During the past season relatively few of the apples on young Baldwin trees in a cultivated orchard were affected with the early form of bitter pit, even though most of the fruits were large.

4. The relation between the occurrence of bitter pit at the time of harvesting and the seed content of the apple.

During the latter part of September and early October, seeds were counted in apples from several hundred clusters, each of which held some fruit affected with stippen. In 108 cases the spur held at least two lateral fruits. In all of these clusters excepting one, most bitter pit was found in the lateral apples having the smallest number of good seeds as compared with other lateral fruits of the same spur. The lateral fruits with comparatively many seeds were entirely free from the disease in 75 of these clusters; in the remaining 33 cases they showed less spotting than the few seeded fruits of the spur. This relationship is also expressed by the data in Table III.

Lot 1 is a composite sample of individual cases in which one lateral apple of the cluster showed the disease while the other fruit was normal. In lot 2 one of the fruits of the cluster had little bitter pit in comparison with the other apple.

In many other cases involving lateral fruits the seeds were not counted, but it was observed that the smaller fruit generally had more disease at the time of harvesting than the larger fruit on the

TABLE III

Bitter Pit and Seed Content

Lot	Relative amount of bitter-pit in apples	Number and quality of seeds in 100 apples		
1	None	358 good	148 medium	183 poor
	Present in all	209 good	180 medium	231 poor
2	Little	291 good	124 medium	224 poor
	Much	139 good	173 medium	228 poor

same spur. Previous studies have shown that the smallest lateral fruit on a given spur has the fewest seeds. It must be remembered that the smallest fruit of one cluster could, of course, be larger than the largest apple of another spur. Many authors report that the large specimens are especially susceptible to bitter pit. Such observations, however, apply mainly to the type of stippen which appears shortly before or generally after harvesting. Besides, the conditions under which the individual fruit developed are not taken into account.

The relationship between a poor seed content and the occurrence of the early form of bitter pit is not very evident when lateral fruits and central fruits of a cluster are compared. In the 110 cases available for this study only 40 per cent of the total number of central fruits had more seeds than the lateral fruit, but more than 95 per cent had less bitter pit than lateral fruits. The seed content of central and lateral apples from the same spurs is given below.

Position of apple	Seeds in 100 Fruits		
Central	246 good	117 medium	191 poor
Lateral	268 good	178 medium	241 poor

This is in accordance with previous studies which have shown that comparatively few good seeds are required to cause the central fruit to remain attached to the spur, while lateral fruits usually require many seeds to prevent abscission.

Furthermore, in a cluster of apples the central fruit with a given number of seeds will generally be larger than a lateral fruit with the same number of seeds. But if the central fruit has very few seeds while the lateral fruit on the same spur has many, the former apple may be smaller. The ability of the central fruit of the cluster to resist the development of bitter pit while the apple

is still attached to the tree is probably due to the same underlying causes which give this fruit the advantage in setting and in the development of good size. But just as the handicaps of a lateral fruit in setting and developing may be overcome by a greater seed content, so likewise is the resistance to the early form of bitter pit increased.

Baldwin spot often appears first on the side of the apples exposed to the sun, but in some cases, at least, the distribution of the seeds within the fruit seems to determine the location of the spots on the surface. This is especially noticeable when bitter pit occurs on apples which are entirely shaded, or when the disease is confined to the green side of the fruit. Relatively few specimens of this kind were observed, but in every case the cavity corresponding to the pitted side had poor seeds or none at all, while the remaining cavities had many plump seeds. Bitter pit occurs on the large many-seeded portion of the apple when the side happens to be exposed to the sun. The direct rays of the sun apparently have the greater influence on the distribution of the disease.

5. The development of bitter pit after harvesting and its relation to the seed content.

About 30 clusters of Baldwin apples involving more than 100 fruits were taken to the laboratory on November 1. The pits which were evident at that time on the surface of about two-thirds of the apples were marked with India ink. After remaining at fluctuating room temperatures for six weeks, the fruit was examined for evidence of further development of bitter pit.

Many new sunken areas appeared on the surface of most of the apples, even on those which were apparently free from disease at the time the fruit was picked. These sunken areas, however, did not discolor the skin as did the pits which appeared earlier. Upon cutting the apple transversely, it was found that numerous pockets of brown tissue had developed within 10-15 mm. from the surface. The brown areas in apples examined in September were confined to within 2 or 3 mm. of the surface. The tissue in the new pits was tasteless or not nearly as bitter as that of older pits. Otherwise there seemed to be very little difference.

The location of the newly formed brown areas showed no relation to the colored cheek of the fruit, but apparently the distribution was determined, at least in part, by the number and quality of seeds in the cavities of the apple. In all unsymmetrical apples, the new pits were more abundant on the large many-seeded side of the fruit, and frequently they were confined entirely to that side. The form of bitter pit which appeared while the fruit was still attached to the tree was often found on the sunny side and sometimes, in shaded fruit, on the side with poor seeds.

Unfortunately, the identity of the individual fruits could not be established with certainty, because the marks on many of the apples became effaced. It was therefore impossible to tell whether the central fruit showed more, or less, new pitting than the lateral fruit of the same spur. The seed content and size of the apple meant little without the facts regarding the character of the spur

and the number of apples in the cluster. Large apples as well as small specimens were badly pitted, and some of both sizes remained free from the disease. The central fruits, too, showed bitter pit. Apples taken from a good common storage on December 15 showed a small amount of stippen, and in these cases it occurred in apples of all sizes. The large apples did not show a greater tendency to the disease than smaller fruit.

6. The condition of the non-pitted tissues of the affected apple.

The seeds in most of the diseased fruits which were examined at the time the fruit was picked during the latter part of September were brown in color, while those from apparently healthy fruits were still white, or nearly so. In several clusters, two lateral apples had the same seed content; nevertheless one showed Baldwin spot, while the other was free from the disease. The seeds in the pitted fruit, however, were brown; those in the normal fruit were white. In a few cases, seeds in spotted fruits were white, but they became brown within a few minutes after exposure to the air, while seeds from normal fruit remained white for more than half an hour. Seeds in apples usually become brown whenever the normal growth of the fruit is arrested or when conditions are otherwise favorable for oxidation.

On September 30 the flesh of normal fruits was hard, crisp and decidedly acid to the taste, while that of diseased fruits yielded readily to pressure, and was agreeably sub-acid. In the case of apples that developed new pits after harvesting, the tissue of the diseased portion of the fruit on December 12 yielded readily to the touch and was often mealy, while the normal flesh in the same fruit was still firm and juicy. Stippen is evidently accompanied by earlier maturity or more rapid decomposition of the tissues surrounding the pits. Early maturity, however, is not necessarily a factor in the development of bitter pit.

7. Bitter pit and water core.

During the past season the conditions which seemed to inhibit the development of stippen before picking time were often associated with the occurrence of water core. But the same conditions which favor the development of water core might also favor the occurrence of bitter pit after the fruit is picked. Water core was more prevalent in fruit on young trees than on old, and it was more common on vigorous spurs in the terminal parts of branches than on weak spurs near the base. The central fruits of a cluster were more frequently affected than the lateral apples, and the largest lateral fruit on the spur often had water core while the smaller apple was normal. In a few specimens, bitter pit occured on the seedless side, while water core occurred on the large, many-seeded side. Exposure to sun seemed to favor the surface appearance of both bitter pit and water core. The seeds in the latter fruits remain white or light brown even after those of normal fruits have attained their brown color.

In some cases water core disappears without apparent injury

to the fruit after the apple is harvested. In other more severe cases the affected tissue breaks down completely. Several specimens have been observed in which new pits had developed in portions of the apples which still showed a few small water-soaked areas as late as December 12.

Discussion

The bitter-pit which appears in the mature fruit that is still attached to the tree seems to be associated with conditions favorable for incipient wilting, but unfavorable for an abundant, or even an adequate supply of nutrients. Such conditions are found on weak spurs near the base of a branch, in small lateral apples that are competing with other fruits in the same cluster, and in fruits, or portions of a fruit, with a poor seed content. Surfaces exposed to the direct rays of the sun become heated and may transpire excessively.

On the other hand, the form of stippen which does not become manifest until the fruit is harvested, or generally several weeks later, seems to be associated with conditions that favor an abundant, or even an excessive supply of water and other size-producing nutrients. Such conditions evidently exist in central fruits, and in many-seeded apples borne on strong spurs located near the ends of relatively vigorous wood.

The so-called true bitter-pit is probably due to the same causes which bring about the earlier appearing stippen. Both forms of the disease may be regarded as a kind of drouth or starvation spot. Apples which are still actively growing shortly before harvest, would be under the same handicaps after removing from the tree as fruit which has poor chances to obtain the necessary water and nutrients during its period of active growth while still attached to the spur. Failure to receive water and other nutrients which are needed to continue growth, or to mature tissue which has not entered its rest period, might, for example, cause changes in the H-ion concentration of the cell sap. Such changes would affect enzyme activity, respiration and other metabolic processes. The result might be a disorganization of the protoplasm and subsequent oxidation of the affected tissue. If these catabolic processes can be checked, by uniformly low temperatures, for example, the appearance of stippen may be delayed, otherwise it soon develops.

Of course only such tissue which is in a condition of susceptibility would be influenced detrimentally by withdrawal of water or lack of additional sap. The protoplasm, no doubt, varies in different varieties, and in a given variety it is probably more susceptible where the young conducting tissues are still too succulent to be prepared for a rest period. Wortmann, in 1892, calls attention to the fact that an excessive application of nitrogenous fertilizer might produce fruit very susceptible to stippen, because the tissue, under such conditions, would probably contain too much organic nitrogen in comparison with carbohydrates which are also needed for the formation of protoplasm and new tissue. This would be

especially true in wet, cloudy seasons which would be unfavorable for assimilation

Seeds and other factors discussed in this paper bear a relation to the development of stippen, probably because they play a part in the phenomenon of incipient wilting, and also because they help to determine the distribution of water and nutrients, and consequently affect the susceptibility of tissue.

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Transpiration Studies with the Apple

By F. P. Cullinan, *Purdue University, Lafayette, Ind.*

THE importance of water in the role of tree growth and plant nutrition, has long received the attention of investigators. In nearly all recent pruning and soil management studies with fruit trees, soil moisture in connection with plant food, its necessary complement of growth, has been considered in its effect on growth and production. The tree as a whole manifests its internal response to the complex, constantly varying mixtures of environmental factors, in amounts of twig and trunk growth; in the amount of foliar expansion; in yield of fruit; and in the quantity of water used in growth which serves as a carrier for food materials.

A study of the literature shows that some investigators have expressed the belief that there may be a relation between this quantity of water which passes from a plant and its metabolic activity, resulting in the acquisition of new organic parts. The measure of this loss of water is expressed in terms of transpiration. Livingston (Botanical Gazette, Vol. 40, 178-195) in working with young wheat plants grown in various media, came to the conclusion that total transpiration is as good a criterion for comparing the relative growth in these media, as is the weight of the plants. Lawes (Lawes, Jour. Hort. Sci London 5:38-63. 1850) expressed the belief that a certain relationship existed between evaporation and rapdity of growth, in that the comparative rate

of evaporation of water to some extent indicated the comparative activity of the processes of the plants.

It had been observed in connection with certain pruning experiments carried on at the Purdue University Agricultural Experiment Station, that a block of young apple trees in one orchard which had been pruned severely, made trunk circumferential growths in some seasons comparable with the growth of equal aged trees, not cut back, and which were under the same soil management in that plot. This orchard is located on a soil in which the tree growth is affected by slight differences in the normal seasonal rainfall. This phenomenon is the resultant of growth processes which necessarily are of different intensities, and which find expression in equal, or approximately so, rates of cambial cell division.

To throw further light on this question and to study if possible any relations which might exist between growth in apple trees, and the amounts of water transpired, experiments were begun in the summer of 1918 on a study of the relative transpiration of leaves of apple trees under different soil and pruning treatments. Studies have also been made on the relative and total transpiration of pepper plants growing in the greenhouse under well defined soil treatments. The data secured, which are the results of three seasons' observations, while not satisfactorily answering the question of transpiration as associated with growth, indicate that under the conditions of these experiments, neither relative nor total transpiration is a reliable index to growth activity in apple trees.

Because of the size of the apple trees which have been subjected to a particular soil and pruning treatment for any length of time, it is manifestly impossible to measure total losses in weight due to the evaporation of water from the foliage. This could only be done with young trees grown in suitable containers. Measurements of actual transpiration are impossible and relative rates of transpiration only can be studied.

The relative rates of transpiration as reported in this paper were determined by estimating the loss of water for unit areas of the same tree when the loss for a measured area was determined. This method shall be referred to as the water displacement method. The principle involved in this method has long been employed. It consisted in measuring the amount of water given off by the foliage in a unit of time. The vapor was absorbed in anhydrous calcium chloride and the amount of water transpired was calculated from the increase in weight of the compound.

Briefly the unit appartus* used for this purpose which was home-made, consisted of two thirty gallon steel barrels which were standardized as to height-volume. These barrels were fitted up with outlet valves to which a glass gauge was attached that registered

*Grateful acknowledgment is due Dr. G. N. Hoffer of the Botany Department of Purdue University and to Prof. Joseph Oskamp of the Horticultural Department who designed the apparatus and gave many helpful suggestions during the course of the experiment.

the amount of water in the barrels at any time. By elevating one barrel above the other on a stand and having the upper barrel filled with water so that it could flow through a tube into the lower barrel, it was possible to obtain a measurable displacement capacity in a unit of time by properly adjusting the valves between the two barrels. The volume of displacement was read on the glass tubes on the side of the barrels. Air displacing the water from the upper barrel entered through a small valve on the upper side of that barrel. This valve was connected by a rubber tubing with the calcium chloride tubes, which in turn were joined closely to a celluloid cylinder in which a single attached leaf was enclosed.

As set up, the calcium chloride tube end of the cylinder was airtight, while the leaf end had an opening through a rubber stopper around the leaf petiole. When the valve is turned in the upper barrel so that water will flow into the lower barrel, and with the system air-tight, air is drawn in around the leaf petiole and passes through the calcium chloride tube where the moisture in the air and transpiration vapor are absorbed, and passes on through the tube to the upper barrel to displace the water in that barrel. When the upper barrel was empty, it was replaced on the stand by the lower or full barrel.

The amount of moisture in a unit volume of air served as a check. This amount was deducted from the water absorbed by the calcium chloride tubes on each of the trees, after the displacement volumes was correlated. The check apparatus was set up in a similar manner to that already described, except that there were no leaves enclosed in the celluloid cylinder.

While the water vapor from the leaves was being absorbed, psychrometer readings, air temperatures, and the temperature within the celluloid cylinders, were recorded. The white spherical atmometer was used to record the rate of evaporation.

Leaves were studied from all relative parts of the tree, viz. on all sides, in different positions on the twigs. The leaves that appeared to be of the same age and in the same relative positions on trees and twigs, were selected for any single reading. This, however, can never be accurately done. All positions are relative only, and especially so on trees under different treatments. The leaves studied were removed from the tree after the reading had been taken and were blue printed. The areas of the leaves of which blue prints were made were determined by planimeter measurements. The amount of water lost was calculated in cubic centimeters per hundred square centimeters of leaf surface.

Now it is not assumed that these determinations are free from sources of error. In so far as possible all such sources were eliminated, but to one investigation transpiration phenomena with plants in the field, it is obvious that many factors must be taken into consideration, some of which cannot be entirely controlled. These all have a very direct and important bearing on the accuracy of the data and particularly, the interpretation placed upon the results obtained. With a plant like a six or seven year old apple tree, a single leaf is a very small portion of the total leaf

surface. However, in making readings, only healthy and typical leaves were chosen. The value of the results obtained lay in the duplication of the readings and the number of observations taken on individual trees. It was found that when more than one leaf was taken it was very difficult, especially with the apparatus used, to make an accurate reading. Enclosing an entire branch in the cylinder gives leaves of different ages which vary in their transpiring power and with trees under different treatments it would be difficult to calculate the amount of water lost per unit area of leaf surface. Other factors which must be taken into consideration with work of this kind are air temperature, wind and humidity.

During the first season, studies were made on trees in a pruning experiment Simultaneous tests were made on the relative foliar transpiring power of leaves on trees which had been cut back, and also on trees which were not cut back. The trees were in their second growing season in the orchard and were under cultivation. The trees cut back had received a heavy pruning which amounted to shortening back the annual growth one-half and thinning out some of the annual growth. The unpruned trees had received no pruning whatever since they were planted. Not more than one tree under each treatment was used during that year. Other trees in the pruning plot were to have been studied and thereby reduce the error from individual tree differences, but the foliage became infected with leaf spot late in the summer, and this precluded making studies on other trees.

The average relative transpiration of water vapor per 100 sq. cm. of leaf surface is here given because of the lack of space for the presentation of detailed tables. Direct comparisons can only be made for the time the readings are taken because factors affecting the rate of water loss may vary hourly. The average, therefore, cannot be taken as an accurate measure for the water loss over a given period, but merely indicate the relative evaporation rate.

The transpiration data obtained from these trees indicate that the pruned trees were transpiring relatively more water per unit area of leaf surface than the trees which had received no pruning. It is interesting to note that both the heavily pruned tree and the unpruned tree under observation, made exactly the same gain in girth during that season, yet the unpruned tree had about 56 per cent greater leaf area than the pruned tree. Furthermore, the average of sixteen unpruned trees showed a girth gain of 2.6 cm. while the same number of trees cut back averaged 1.8 cm. of girth gain.

If the remainder of the foliage on the trees transpired at the rate of those leaves under study, the trees then, that had not been cut back, would actually transpire more water during the growing season (because of their greater leaf surface) than the trees which had been pruned, yet the rate of transpiration per unit area of leaf surface was greater in the case of the unpruned trees. There was no way to measure the actual water loss from the trees under these conditions. That this rate of transpiration doubtless occurred

with other trees in the pruned and unpruned block, is suggested by leaf weights taken on August 7th at 11 A. M. Fifty leaves were picked from two year old trees in a block in the pruning experiment, and placed in airtight glass jars. These were weighed green, dried in an oven for two days at a constant temperature and then were reweighed. The following table gives the results obtained.

TABLE I

Row	Number of trees	Treatment	Per cent moisture in 50 leaves
II	16	Unpruned	54.9
V	16	Pruned	57.4
VII	16	Unpruned	54.8
IX	16	Pruned	55.9
XII	16	Unpruned	54.9

It will be seen from Table I that the per cent of moisture present in the leaves of unpruned trees is very uniform, and that the leaves of pruned trees contained from one to two and one-half per cent more moisture when the samples were taken than the foliage from unpruned trees. It should be stated that the rainfall at Lafayette during the growing season of 1918 from April to July was about 1.8 inches below the normal for that section or about 50 per cent below the normal for the months of June and July. The air temperature during the month of July when the studies were made, was high and the atmometer showed a high rate of evaporation. The soil in this orchard is underlaid with a gravel subsoil, and short periods of drouth are soon observed in the effects on tree growth. These conditions are mentioned because of the influence they may have on the moisture content of the foliage of trees with a large leaf surface. The foliage of pruned trees was thicker and heavier and from our knowledge of the pressure occurring in very actively growing branches, the moisture in the leaves may have been drawn from the soil solution by osmotic pressure. Yet we do not know that absorption of nutrients was also taking place in the plant, or were being carried into the plant parts by the transpiration stream.

In the summer of 1919, studies of foliar transpiration were made at Laurel, Indiana, on four 11 year old apple trees. Two of these trees were in grass in a straw mulch plot which had received a heavy mulch of straw from the time the trees were planted. The other trees were in a sod block in which the grass was cut and allowed to fall back on the ground. The soil is a very poor clay, deficient in plant food. In this case the trees had received the same pruning treatment and the differences in the growth of the trees were due to the soil treatment. The 11 year old trees in the straw mulch plots had averaged over 33 per cent more gain in trunk girth per tree, and produced over nine times as much fruit as was produced by the trees in sod during the same period of time.

Using the water displacement method above described for measuring the foliar transpiration, a total of 27 readings were made on leaves of trees in the straw mulch and sod block. There was a total of 79 leaves used on each plot during the experiment. Of these the foliage of trees in sod averaged .9550 c. c. and that of straw mulch trees averaged .7307 c. c. of moisture transpired per hundred sq. cm. of leaf area, per one-half hour with 40 liters of air passing over the leaves during the 30 minutes. The total rainfall at Laurel during June and July when the studies were being made was about two inches below normal. The foliage of trees in the sod plot were transpiring at a relatively greater rate per unit of leaf area than were the more vigorous trees under straw mulch.

During the past season studies were made on these same trees in the months of June and July. A total of 53 readings was made. The average transpiration per hundred sq. cm. of leaf surface in 40 minutes of time, was for the foliage of trees in straw mulch, 1.1478 gr. of moisture and for the foliage of trees in sod .9538 gr. of moisture. The data obtained during this year indicated that the foliage of trees in straw mulch was transpiring relatively more moisture per unit area of leaf surface than the foliage of trees in sod. This is just the reverse of transpiration rates obtaining in this orchard during the previous year. However, during the past year the rainfall was greater and well distributed over the growing season. The average maximum and minimum temperatures and the rate of evaporation from atmometers in the field, were no higher than they were during the same months of the previous season. A greater supply of moisture was available during 1920 and the trees made a correspondingly greater increase in growth over that of 1919.

During 1919 trees in cultivation and heavy straw mulch made less trunk growth than was made in 1918, while trees in sod showed a slight increase over the growth made during the previous year. These results are shown in the following table.

TABLE II

Treatment	Number of Trees	Average girth increase per tree in centimeters			Average leaf area in sq. cm.	
		1918	1919	1920	1919	1920
Cultivation	73	5.90	5.71	6.86	......	......
Straw Mulch	38	5.54	5.40	6.53	25.28	29.46
Sod	50	4.17	4.81	5.30	22.12	26.85
		1918	1919	1920		
Rainfall, June, July and August	......	9.86	9.41	9.41	......	......

These data suggest an explanation for the rates of relative transpiration obtained on the sod and straw mulch plots in 1918-19. The trees growing in sod are maintaining growth under a subnormal condition of food and moisture, and are not so readily affected by a decrease in the water supply as are trees growing under

conditions where they have developed a vigorous growth and a large leaf surface, dependent upon an optimum supply of food and moisture for a continuance of this growth. Livingston (Bot. Gaz. Vol. 53:309-330) has shown, that under desert conditions, there may be a fairly large reduction in the percentage of moisture in the leaves that would not be detected by the appearance of the leaves. Chandler (Proc. of Soc. Hort. Sci. 1914:112-116) has pointed out that there may occur fairly large incipient dryings in late summer in the leaves and fruit of old trees, in which there are probably large resistances to water movement. Relative transpiration of the foliage of such trees would, therefore, not be a reliable index to the growth activities of the tree.

Further proof of this statement is afforded by experiments conducted in the greenhouse during the winter of 1919-20 under controlled conditions of temperature and humidity, and where plant food and moisture should be applied to the plants under study, in known quantities. The common pepper, *Capsicum annuum*, of the Ruby variety, was used for this work. It was chosen because its foliage would best lend itself to studies with the transpiration apparatus being used, and because its response to certain treatments would to a certain extent be comparable to that of an apple tree. The soil conditions for growth were to approximate those obtaining in the orchard where the trees were studied under soil management systems of straw mulch and sod.

The seedlings were grown in flats and later were pricked off into individual two and four inch pots as they increased in growth. They were transferred when about eight inches high to Wagner pots containing a very poor soil, of a mixture of silt and clay. Here the plants were given the various treatments when they had become established in this soil. One plant was used to each pot and there were six pots in a single treatment. All plants in the different series used were selected as uniformly as possible.

The plants were grown under the following set of conditions:

1. High moisture and deficient nitrate.
2. High moisture, pruning and deficient nitrate.
3. Low moisture and deficient nitrate.
4. Low moisture, pruning and deficient nitrate.
5. High moisture and nitrate.
6. High moisture, nitrate and pruning.
7. Low moisture and nitrate.
8. Low moisture, nitrate and pruning.

The purpose of the pruning was to decrease the leaf surface under certain conditions of growth. It consisted of the removal of small portions of the stem and leaves from the ends of the main branches. Studies were made of the relative foliar transpiration of these plants and in addition, total transpiration was studied by weighing the pots at frequent intervals. The loss of water by transpiration and evaporation was made up by adding the amount required to bring the amount of moisture in the pots up to the amount maintained. The maximum water retaining capacity of the soil was

determined, and conditions of high moisture were maintained by keeping the amount of moisture in the soil at 50 per cent of its water holding capacity calculated on a dry basis. It was thought that this degree of soil saturation would be about optimum for growth. One-half this amount was used for soil conditions of low moisture content. Nitrate was added at the rate of one part per 3,000 of soil. Two pots with no plants in them were used as checks. All water was added to the Wagner pots by sub-irrigation and a dust mulch was kept over the surface of the soil in all pots to retard the evaporation of moisture from the soil. Study of these plants under the various treatments described covered a period of 81 days. The following table gives the average total transpiration per plant occurring during that time, and the growth resulting under the various treatments of moisture and nitrate.

TABLE III

Number of Plants	Treatment	Average leaf surface per plant in sq cm	Average water loss per day per 100 sq. cm of leaf surface	Average dry weight in grams*	Loss of water per grams dry weight*
6	High moisture	625.65	8.37	12.8378	.652
6	High moisture, pruned	504.48	9.60	9.2386	1.039
6	Low moisture	602.03	2.53	9.5318	.265
6	Low moisture, pruned	291.90	3.49	7.3355	.476
6	High moisture and nitrate	1263.40	8.23	23.4442	.351
5	High moisture, nitrate and pruned	1261.56	7.90	21.6905	.364
5	Low moisture and nitrate	1150.84	3.15	19.8187	.158
6	Low moisture, nitrate and pruned	833.00	3.90	15.5934	.250

*Does not include fruits.

The data in all cases show the very marked effect of the removal of small portions of the stems and foliage in the reduction of the total leaf surface, and the amount of dry matter produced. Where the amount of moisture was low, or where there was a deficiency of both moisture and plant food, the plant with the smaller leaf surface transpired relatively more water per unit area of leaf surface, but that plant did not accumulate as much dry matter as the plant with the greater leaf surface. However, where there was an optimum supply of moisture and an available supply of nitrates, the greater was the total amount of water transpired, the greater was the supply of dry matter produced, and the smaller was the amount of water used per unit of dry matter under the conditions of this experiment.

The relative rates of foliar transpiration of the pepper plants per unit area of leaf surface studied at different periods during their growth, follows very closely the total transpiration for the 81 day period. The following table gives the average rate of transpiration for plants in the various treatments.

TABLE IV

Number of readings	Treatment	Transpiration per 100 sq. cm. of leaf surface in c.c.	Average dry weight in grams	Time
10	High moisture, ...	1.2038	12.8378	90 min.
10	High moisture, pruned, ...	1.920	9.2386	90 min.
10	Low moisture, ...	1.637	9.5318	90 min.
11	Low moisture, pruned, ...	1.812	7.3355	90 min.
10	High moisture and nitrate, ...	1.674	23.4442	90 min.
9	High moisture and nitrate and pruned, ...	1.563	21.6905	90 min.
12	Low moisture and nitrate	1.260	19.8187	90 min.
11	Low moisture and nitrate and pruned, ...	2.005	15.5934	90 min.

These data help to explain the results obtained in a study of the relative transpiration of apple trees under systems of soil management and pruning which affected the growth of trees. They indicate that the rate of transpiration is independent of the strength of the soil solution.

As Kiesselbach has stated (Neb. Agr. Exp. Sta. Research Bul. 6) in a fertile soil the plant continues to increase in dry matter in a thrifty manner all of the time that it is transpiring water. In an infertile soil, the plant continues to transpire water, but there is not a coincidental increase in dry matter. Hasselbring (Bot. Gaz. Vol. 57) in working with the tobacco plant in Cuba, has shown that plants growing in the open transpired about ten liters more water than those grown under shade, yet the quantity of dry substance produced was the same in both cases.

In view of the results obtained with pepper plants in the greenhouse and fruit trees under field conditions, it seems quite conclusive that the mere passage of water through the plant has no influence on assimilarity activity, provided the water supply does not fall below a certain minimum required to maintain the turgor of the cells.

Because of the many factors which may affect the growth of plants, particularly moisture and plant food and the resulting variations in the transpiration rate, relative or total transpiration is not a reliable index to growth activities in the plant.

The results presented in this paper are not given because of the practical application which they may have, but rather that they may be of value to those interested in studies dealing with the water needs of fruit trees, or in interpreting the results of orchard cultural experiments in sections where varations in the water supply may be a prime factor in tree growth.

Pruning Notes on Blackberry Varieties

By A. S. Colby, *University of Illinois, Champaign, Ill.*

IT HAS long been a horticultural principle that a correct understanding of fruiting habits of various plants is essential in order that they be properly pruned. Exact information as to fruiting habits is being worked out and made generally available for many of our fruits and serves as a basis for correct pruning practice. However, with some of the brambles, especially the blackberry, specific information as to fruiting habits is very meager.

It will be remembered that the roots of the blackberry are perennial and the stems biennial. These woody stems grow the first year and die after fruiting the second year. It follows that the old canes should be removed sooner or later after the bearing season is over and the remaining canes, one year old, thinned out more or less, depending upon the method of training practiced. In some cases the young canes are tipped back in spring as they reach a height of approximately 2 feet, to induce the growth of vigorous laterals the same season.

After the rows have been thinned, the next step is to cut back the canes and laterals. Judgment is required in this operation, which is in effect a fruit thinning process. Too heavy pruning of the laterals will prune away the promised crop, while too little will leave more fruit than the plant can properly mature. However, the question as to the degree of severity in pruning is usually left unanswered, with the statement that the length to leave the laterals depends upon the variety and the pruner will be obliged to learn by experience the correct amount of wood to leave.

During the last two seasons the writer has observed the fruiting habits of several standard blackberry varieties. It is his purpose to present a brief progress report at this time on that topic, with recommendations as to the amount of pruning for certain varieties to produce maximum results. The observations were made on the blackberry variety plantation of the Department of Horticulture at the University of Illinois.

In one plat, 11 varieties are grown in double rows for each variety. Each series of double rows is gone over at intervals annually in spring and pinched back as the growing canes reach a height of 18 inches to 2 feet. Some canes are missed in this operation and, therefore, grow taller and do not branch. The dead, diseased, weak, and crowding canes are cut out during the winter season. The yearling canes in one row of each variety are pruned back severely as to canes and laterals while the other row is left without any further pruning than before mentioned. Observations are made as to fruiting habits and influence of pruning.

The writer would group blackberry varieties studied as follows: First, those which carry their cluster-buds well in toward the base of the laterals and well down on the canes; second, those which carry their buds out nearer the tips of the laterals and canes; and,

third, those whose buds are scattered fairly well along the productive wood.

Varieties observed as belonging to the first group carrying the cluster-buds well in are Ward and Lawton. Fruiting clusters were rare on the first 5 buds counting back from the tip. The number of buds to a lateral varied from 8 to 14. Cutting back moderately, that is, removing up to one-half of each lateral, should have little effect in reducing the yield. It was found that the row where the laterals were cut back approximately one-half, produced as many fruiting clusters as where no pruning was done. It is recommended, however, that moderate pruning be practiced to facilitate cultivation and harvesting.

In the second group, which includes the varieties carrying their cluster-buds well out near the tips of canes and laterals, are placed the Early King, Taylor and Wachusett. It is obvious that close pruning of these varieties will reduce the crop materially. As a general rule, the first 3 to 5 buds next to the main cane on each lateral do not produce fruit. With an average of 15 buds to a lateral, enough will be left for maximum production if about 5 buds, or one-third the lateral, be cut away. Any unbranched canes remaining are cut back to 5 feet in height.

Varieties in the third group, those in which the cluster-buds are fairly well distributed over the productive wood, include Snyder, Ancient Briton, Wilson, Ohmer, Eldorado and Mersereau. Our most vigorous and productive varieties are included in this group. It is, consequently, the one from which our most important commercial blackberries are drawn.

Severity is more necessary in pruning this group than either of the two others. Many of the laterals carry up to 18 buds each. These buds usually blossom and attempt to bear fruit. As a result, too many berries are produced for the plants to ripen properly and the fruit is small, seedy and poor in quality. It was found the best practice to cut back the laterals one-half, reducing the number of buds to from 7 to 9. With this degree of severity, the buds remaining produced the maximum amount of good quality fruit. Unbranched canes should be cut back to 4½ feet in height.

Blueberry Culture in Minnesota—A Report of Progress*

By W. G. Brierley, *University of Minnesota, St. Paul, Minnesota,*
and
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THE "lowbush" blueberry, *Vaccinium Pennsylvanicum*, grows profusely in the wild in the northeastern quarter of Minnesota, a section in which fruit culture is largely restricted to the small fruits on account of the severe winters. The crop from the wild plants is marketed in considerable quantities and the proceeds constitute an important portion of the income of the settlers in this region. The economic value of this fruit crop attracted attention and stimulated interest in the possibilities of its cultivation and improvement. Also the work of Dr. F. V. Coville of the United States Department of Agriculture with the "highbush" species, *Vaccinium corymbosum*, indicated that the native lowbush blueberry might be brought under cultivation. In the summer of 1914, Dorsey and Valleau selected some plants at Cloquet, Minnesota, on the basis of the berry and studied berry types. Discussion of this work led to a preliminary study of ascxual propogation of the lowbush blueberry in 1916 by the Divisions of Horticulture and Forestry of the Minnesota Experiment Station. The results in 1916 led to the organization in 1917 of a station project carried cooperatively by these divisions. The work has been carried on at the Forest Experiment Station, Cloquet, Minnesota.

The soil at Cloquet is a typical jack pine sand or sandy loam in which the wild blueberry flourishes. Practically all of the work has been done in the station nursery, which has been cleared for some years and used for growing conifer seedlings. The surface is gently sloping towards the north. The water system used for the nursery provides an ample supply of lime-free creek water for irrigation when needed.

Propagation Studies

When the preliminary studies were begun in 1916, the object was to find out how to propagate the lowbush species as a basis for later cultural work. This is a much smaller species than the highbush species with which Coville has worked, and it seemed likely that it might respond to different treatment. The propogation methods which seemed practicable with the material available from the wild were as follows:

1. Stem cuttings, year-old wood. Taken March 1 from under the snow and placed in root cellar to callous.

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2. Stem cuttings, year-old wood. Taken May 12 before growth had started.
3. Heel cuttings, year-old wood.
4. Stem cuttings, year-old wood, with portion of older wood at the base.
5. Stem cuttings, old wood.
6. New rhizomes, with portion of root attached. Separated from the parent plants before the tips had emerged from the ground.
7. One-year-old shoots from rhizomes, with portion of root attached.
8. Old rooted plants, tops cut back.
9. Root cuttings.

As this work was planned to furnish indications for later studies, no very detailed records were taken. Practically all of the cuttings without roots attached failed entirely. Only a few individuals showed signs of growth the first season, and fewer still were alive the following spring. Lots 1 to 5, in which no roots were used, did not show one per cent of success and lot No. 1, late winter cuttings, showed no advantage over lot No. 2, spring cuttings, in regard to callous development. Lots Nos. 6 to 9 showed the value of the use of the roots or rooted stems in propagation as all of these lots did much better than any of the others. The old rooted plants in lot No. 8 made a weak growth, evidently due to the lack of vigor in the old wood. Lots Nos 7 and 9 showed the most promise.

In the fall of 1916, material was collected from wild and made up into lots identical with those listed above except that lot No. 8, old rooted plants, and lot No. 1, late winter cuttings, were omitted. All this material was heeled in in the nursery. It was thought that material prepared at this time would be in better condition than material prepared in the spring. Growth starts so rapidly when the snow melts and the frost leaves the ground in the spring that it was supposed cuttings would not be dormant and would not grow readily. Preparation in the fall showed no advantage, however, and root cuttings and new rhizomes with roots attached appeared to be somewhat weakened as they did not do as well in 1917 as the lots grown in 1916. As in 1916, the lots without roots attached resulted in failure, although a few pushed out leaves and lived until mid-season. Of lot No. 6, new rhizomes, 5 per cent grew, but nearly all of these failed during the season. Of lot No. 9, root cuttings, 15 per cent grew, and of lot No. 7, year-old shoots from rhizomes with a portion of root attached, 55 per cent grew.

The results with the young rooted shoots in 1916 were so promising that this method was adopted for use when the culture plots were set out in the spring of 1917. In five of these plots[1] handled under what would now be considered the best systems of culture, 250 plants were set. Of these, 218 were alive and vigorous in 1919, or 82.2 per cent. A considerable number of superior plants were

[1]Table I, Plots 2, 3, 4, 5, 6.

selected in the wild in 1919. The success with the young rooted shoots led to this method of propogation when these selected plants were dug and prepared for nursery planting in May, 1920. A total of 2,084 rooted shoots were lined out in nursery rows at this time. On July 23 the plants were showing a fair growth, although 20 per cent had so far failed to develop leaves, but many of those without leaves appeared to be alive, with possibilities for shoots to appear from the root. In September these were examined again and 85 per cent were growing. A final count will be made on these plants next year, but at least 85 per cent of success is assured. One may judge from these results that it is safe to rely on this method for the propagation of the lowbush blueberry.

Natural Propagation of Wild Plants

A study of the natural propagation of wild plants was made in 1920. The lowbush blueberry (*V. Pennsylvanicum*) spreads readily by means of branching underground shoots or rhizomes. These shoots generally develop for a few inches as a single stem; then they divide into two to five, or more, shoots. These branches often appear all at one point and spread like outstretched fingers. When the branches, or shoots, have grown for 6 to 12 inches the tips turn up and emerge from the soil. Foliage develops as soon as the tips emerge, followed by the growth of a few short, leafy shoots. The underground portion of the stem at the same time begins to develop roots and the new stems are practically independent of the parent plant after the first season. One vigorous plant may develop into a colony in this way in a few seasons. Such colonies frequently cover the ground near an old stump and sometimes will cover a square rod of area. This study very probably should have preceded the propagation studies, but it served to explain some of the results of that work. The young rhizomes are not well enough developed to grow independently of the mother plant. The plant evidently renews itself regularly and old roots and stems lose vigor in three or four years, thus accounting for the failure of old rooted plants and root cuttings. After the young shoot from a rhizome has established itself for a season it is well able to care for itself and may be used successfully in propagation.

Culture Studies

A series of plots was laid out in the spring of 1917 to study the effect of various cultural methods upon growth and fruiting. Each plot consisted of fifty plants laid out in five rows of ten plants each and spaced approximately one foot apart each way. This type of plot was used because it was the standard size of plot in the forest nursery. Young shoots with a portion of root attached were used throughout and all plants were watered after planting to give all a good chance to start.

Eight plots were established for the following kinds of treatment:

Plot 1. No care.
" 2. Cultivated.
" 3. Cultivated and watered.
" 4. Half shade and cultivated.
" 5. Half shade, cultivated and watered.
" 6. Two-inch mulch of peat. Weeded.
" 7. Two-inch mulch of peat and manure. Weeded.
" 8. Two-inch mulch of manure. Weeded.

The half shade was obtained by using a lath screen supported by pipes at a height of 15 inches from the ground. Plot 1 was cultivated once by mistake and was watered once. Rainfall throughout June and July made it unnecessary to water frequently, only two or three waterings being given to plots 3 and 5. For this reason there was very little difference in treatment between plots 2 and 3 or between plots 4 and 5. The season of 1918 was generally comparable to 1917 in regard to rainfall, there being no protracted periods of drouth. Table I shows the response of the plots to the different cultural treatments.

TABLE I

Effect of Different Cultural Treatments Upon the Stand and Vigor of Plants.

Plot No.	Treatment	Percent Plants Alive July, 1917	Percent Plants Alive July, 1918	Remarks
1	No care	80	60	Appearance very poor. Only 28 per cent vigorous.
2	Cultivated	80	78	Generally vigorous; foliage red-tinged.
3	Cultivated and watered	74	70	Not as vigorous as Plots 2 and 6.
4	Cultivated and shaded	86	94	Less vigorous than Plots 2 and 6.
5	Cultivated, shaded and watered	82	92	Less vigorous than Plots 2 and 6.
6	2-inch peat mulch	82	92	Vigorous.
7	2-inch peat mulch and manure	36	66	Not vigorous.
8	2-inch manure mulch	40	38	Poorest plot.

This table shows that neglect resulted in a poor stand of plants which generally were weak. Manure alone or in combination with peat, is detrimental, probably due to its alkaline nature. Plots 4, 5, 6 and 7 showed an increase in the per cent of plants growing in 1918 over 1917, but No. 7, the peat and manure plot, was very weak. The cultivated plots showed a smaller percentage of stand than the plot under shade or peat treatments, but the individual plants largely were of good vigor. The shaded plots in which a

high percentage of plants was growing, did not show as much vigor as the cultivated plots. The peat plot was the best of the lot in vigor and had as good a stand of plants as the shaded plots. Some of the differences in plant stands may be attributed to the variations in vigor among the wild plants or to varying lengths of root on the plants as set.

In 1919 the plots were weeded and watered in times of drouth. In this season the peat mulch plot again showed the best vigor and stand of plants, with shade a close second, and cultivation third. The best growth of shoots was made under shade, with cultivation second, and peat mulch third. This advantage of growth under shade, however, appeared to be in length only, as the shoots were not as stocky. In fruiting, cultivation gave the best crop, the best quality of berries, and the largest clusters of berries. Peat mulch was a very close second, but shade showed poorly, both in production and quality. As the production of fruit is of chief importance, it would appear from these preliminary studies that either cultivation or peat mulch would be satisfactory. While shading gave very good plant growth, it is doubtful if this method is practicable on account of the poor crop and the cost of screens.

It is of interest to note that the number of berries in the clusters on the cultivated plots often were greatly increased over the usual number to be found in the wild from which the plants were taken. This increase did not show markedly on the other plots. In 1919 in the wild[2] the average clusters varied in number of berries up to 12 or 15. In plot 2, under cultivation, a considerable number of clusters showed from 20 to 30 berries of good size. In Plot 3, also cultivated, clusters of 30 to 40 berries were frequently found and a half a dozen clusters were found in which the number of berries ranged between 60 and 70. Evidently this increase in the number of berries to the cluster must be attributed to the effect of cultivation. It should be noted further, however, that these clusters appeared to ripen more slowly than the smaller clusters. Some large clusters did not reach the dark blue color stage, although sweet in flavor. Miss Elizabeth C. White of New Lisbon, New Jersey, reports a detrimental effect upon the berries in *V. corymbosum* from overbearing and it is possible that the same effect appeared with *V. Pennsylvanicum*, although in lesser degree.

In 1920 all the plots except 2, 4 and 6 were discontinued, but the best individual plants were transplanted and will be watched carefully in their new location to see if they continue to hold their superiority over other plants. Plots 2, 4 and 6 were continued through the season and compared in vigor and fruiting. In plot 2 (cultivated) the best plants were superior to the best plants in peat or shade, although the fewer number of plants in the plot, some of these being weak, gave the plot a slightly irregular ap-

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[2]The stock for these culture plots was taken from the colonies selected by Dorsey and Valleau in 1914. The number of berries per cluster in these colonies in 1919 was not above the average of other plants in the wild.

pearance not found in plots 4 and 6. Two plants from this plot were dug for photographing in the spring of 1920, thus adding to the irregular appearance. The plants bearing large clusters in 1919, again in 1920 showed clusters above the seasonal average of plants in the wild. In 1920 the number of berries to the cluster ranged from 10 to 20, which was far better than any clusters found in the wild, and slightly better than on plots 4 and 6. Little change was noted for plots 4 and 6, except that in plot 6 (shade) the quality of the berries appeared to be equal to that of the other plots and the berries were slightly larger in size. All of the plots were thickening up in plant stand, particularly the peat mulch plot, due to the natural spreading habit of the plants. In vigor and yield the 1920 results were similar to the results of 1919, showing cultivation or peat mulch to be almost equally satisfactory as culture methods.

Renovation in the Wild

The subject of culture cannot be passed without reference to a study of the possibilities of renovation in the wild without recourse to burning. Square rod plots were selected in a good wild blueberry stand in 1917. One plot was mowed with a bush scythe, cutting close to the ground. Another plot was grubbed over to remove all growth but the blueberries. Check plots left untreated were laid off alongside. In 1917 the blueberry plants in both the mowed and grubbed plots seemed to be invigorated. In 1918 frost killed the blossoms and during that season sweet fern and other wild plants grew faster than the blueberry plants. In 1919 and again in 1920 it was very evident that treatment of either kind stimulated the other wild growth more than the blueberries. On account of the danger of forest fires it is very evident that burning is not a safe method to use in northern Minnesota. As such promising results have been obtained from cultivation and peat mulch where other plants can be excluded easily, it would appear that efforts at renovation in the wild are unprofitable.

Selection of Superior Wild Plants

As the wild plants vary greatly in vigor, yield, size of fruit cluster, and size and quality of the berry, it was evident, when the work was started, that an effort should be made to select the best of the wild plants for cultivation. Frosts and cold rains during the blossoming period greatly reduced the crops during the first three years of the work. In 1919 the crop in the wild was excellent, affording a good opportunity to select the best plants. Some 44 selections were made on the basis of vigor, superior yield, quality, or size. Some of the selections were of considerable promise, one in particular being productive, of good quality, and averaging five-eighths inch in diameter. A few selections were made in the spring of 1920 on the basis of vigor and abundance of bloom. Some selections were made in July, 1920, while the plants were fruiting, but the crop was light and the opportunities not as good as in 1919.

In order to identify the selected plants a tree label was attached to the stem and a lath stake set in the ground beside the plant. Where colonies were selected, some of the plants were labeled and the colonies roughly outlined with the lath stakes. As some of the stakes were pulled up by pickers or others and a few selections lost, all of the selections in 1920 were located with reference to landmarks as well as with stakes and labels.

All of the 1919 selections which could be located and the 1920 spring selections, were dug in late May, 1920. Clumps of plants and soil were hauled to the nursery where the young rooted shoots were worked up for planting. There are 2,084 of these in the nursery and at least 85 per cent are growing as previously stated. These selected plants will have to be tested thoroughly to determine their value under cultivation.

Work with *Vaccinium Canadense*

In the earlier work *Vaccinium Canadense*, the swamp lowbush blueberry, was considered too poor in quality to be worth much attention. However, later studies show this species to bloom a little later than *V. Pennsylvanicum* and it also ripens its fruit later. In the last two seasons fruit from this species has been picked in early September and the quality seems to improve after the early part of the season. As it is evident that these characteristics make the species of interest, several selections of superior wild plants were made in 1920. These will be grown with the selections of *V. Pennsylvanicum* for the purpose of comparison.

Work with *Vaccinium corymbosum*

The highbush blueberry *Vaccinium corymbosum* is not native to Minnesota. As the species grows wild in northern states where the climate is only slightly less severe than in northern Minnesota, apparently it may be introduced into Minnesota with some prospects of success. If the attempt is successful a fruit plant of high economic value will have been added to the limited list of fruits for this section. A limited attempt to introduce this species was begun in 1916 when twenty plants were obtained from Dr. F. V. Coville of the United States Department of Agriculture. So far these plants have not been able to stand the winters at Cloquet, killing to the snow line if exposed. In some years they have not matured early enough and may have killed back for this reason.

In 1919 a cooperative agreement was reached with the United States Department of Agriculture under which 732 untested seedlings from certain crosses made by Coville were planted. Some of these are of selected *V. corymbosum* stock and some of *V. corymbosum* x *V. angustifolia*. Work with these plants has not progressed far enough for conclusions to be drawn.

Fruit Bud Production in the Apple

By T. J. MANEY AND H. H. PLAGGE, *Iowa State College, Ames, Iowa.*

THIS study of fruit bud production in the apple originated in connection with an orchard humus investigation which has been conducted since 1910 by the Pomology and Soils Sections of the Iowa State College, in a 20 acre orchard near Council Bluffs, Iowa. The method of procedure in this project is to vary the amounts of humus in the soil by different methods of soil culture, viz., clover sod, blue grass sod, cover crops, and clean cultivation, and to measure the effects of the soil treatments on growth, productiveness and longevity of the trees.

The orchard is divided into six plots as follows: 1. Clover sod. 2. Cover crop. 3. Clean cultivation. 4. Blue Grass sod. 5. Cover crop. 6. Clover sod. Each plot contains the following varieties: Grimes, Jonathan, Northwestern Greening, and Winesap. Sheriff is included in all plots with the exception of the clover sod.

Thus far soil determinations have failed to indicate the wide differences which are shown in the behavior of the trees on the various plots, although the soil type is the Missouri loess which is recognized for its uniformity of texture and composition.

The soil analyses have been made at regular intervals. Generally they have shown a greater variation between samples taken in the same plot than between samples taken in different plots. In most cases the differences shown between samples from different plots are too slight to furnish any tangible evidence on the differences which now exist in growth production and longevity of the trees growing under the various conditions of soil management. If much importance is to be placed on soil analysis as an adjunct in interpreting the effect of fertilizers, then there is an urgent need for refinement in the present method of soil analysis.

It is worth while to note here that all the varieties named have not been able to withstand the conditions imposed by the methods of soil management. The Grimes has been entirely killed out as the result of winter injury on the cover crop and clean cultivated plots, but has remained uninjured on the sod plots. Jonathan and Winesap have also suffered severe injury on the cover crop and clean cultivated plots. The most severe injury occurred during the winter of 1917-18. Northwestern Greening because of its superior hardiness, has withstood its environment and the original planting of about 200 trees stands today in a vigorous, growing condition. Incidentally this variety furnishes an excellent demonstration of the value of hardiness in a variety.

The striking feature of the Northwestern Greening trees is the low production on the blue grass plot, and with this low production is an apparent correlation of low growth in twig, trunk circumference and leaf. On the other hand, the production of the clover sod, clean cultivation and cover crop trees, is high, and the growth in twig, trunk circumference and leaf, is also high. The

blue grass trees, now 30 years of age, have averaged three bushels per tree per year less than the trees of the same variety on the other plots. When the experiment was laid out, all of the trees of this variety were in a like condition in regard to size and vigor. In this particular experiment we have an indication that tree growth is seemingly an important adjunct in interpreting the effect of soil treatments on yield.

The Northwestern Greening on the blue grass sod plot has been an off year bearer, whereas the trees of the same variety on the other plots have borne annual crops. It was the behavior of these Northwestern Greening trees which led us to make a study of the fruiting wood during the season of 1920.

After giving the trees a careful study, it became apparent that the general term "fruit spurs" was not a workable designation for fruiting wood and so three distinct groups of fruiting wood were considered: Group A—Terminal fruiting wood. Group B—Lateral fruiting wood. Group C—Old fruit spurs.

For convenience of study and for reasons which seem logical, different types are recognized under each of these groups and are classified as follows:

Group A—Terminal Fruiting Wood.
- A-1—Apical fruit bud on strictly terminal growth.
- A-2—Lateral fruit bud on strictly terminal growth.
- A-3—Apical or lateral fruit bud on terminal growth which is a secondary growth from a fruit stalk on terminal growth.

The last division of this classification seems rather arbitrary, but still it seems plausible since the formation of the fruit stalk undoubtedly affects the subsequent growth of the twig in very much the same manner in which a pruning wound disturbs terminal growth at the point where a terminal is headed back. Oftentimes such a stalk or pruning wound will cause the production of two or more vigorous secondary growths.

Group B—Lateral Fruiting Wood.
- B-1—A lateral fruit bud produced on two year old wood. This bud was vegetative on the one year old terminal growth.
- B-2—A fruit bud produced on a lateral spur of two or more years of age.

Group C—Old Fruit Spurs.
- C-1—Fruit bud produced on a secondary growth springing from a fruit stalk on an old spur. The stalk had produced a fruit the same year the growth was produced. Fruiting of such a bud implies annual bearing at least for two years in succession.
- C-2—Fruit bud produced as a terminal growth on an old fruit spur. No fruit was produced for at least one year previous to the formation of the fruit bud. This is the common type of fruiting on old spurs.

TABLE I

	TERMINAL					LATERAL			OLD FRUIT SPUR		
Plot	Buds Examined	Percent A-1	Percent A-2	Percent A 3	Total percent. A's	Percent B-1	Percent B-2	Total percent B's	Percent. C-1	Percent C-2	Total percent C's
1. Cultivated and cover crop	774	23.44	.6	16 34	39.84	5.04	26.26	31.66	6.76	21.37	28.13
2. Clover sod	1187	17.41	3.14	10.75	31.30	5.58	25.75	29.33	3.27	36.13	39.40
Sub total	1961										
Average 1 and 2	....	20.42	1.87	13.54	35.57	4.49	26.00	30.49	5.01	28.75	33.76
					+12.85						
3. Blue grass	1097	11.71	.42	10 59	22.72	2.46	32.69	35.15	1.35	40.69	42.04
Total	3058										
Average 1, 2 and 3 ...	....	17.52	1.38	12 89	31.28	3.81	28.23	32.04	3.79	32.73	36.52

With this classification in mind a record was made as to how the Northwestern Greening trees growing on the clover sod, cover crop, cultivated, and blue grass sod plots produced their fruit. The record was made after the June drop had occurred. The season of 1920 was the on year for the trees on the blue grass sod, and theoretically the off year for the trees on the other plots. The year previous (1919) the trees on blue grass had averaged 69.7 pounds per tree, while the trees on the other plots had averaged 629 pounds per tree. The yield of these trees in 1920 will perhaps equal that of the trees on the blue grass. A tabulation of the data which were collected is given in Table I. The outstanding feature revealed by these figures is the fruiting performance of the terminal growth. The importance of this type of growth as a factor in fruit production is suggested by the fact that 31.28 per cent of the fruit on the trees on all plots was borne on terminals of one year's growth.

The clover sod, cultivated, and cover crop trees, show an increase of 12.85 per cent in terminal fruiting wood over the blue grass sod trees.

In general, investigators have recognized terminal fruiting when studying fruit spurs, but few have attached much importance to it except for mentioning that it is a feature connected with certain varieties. Roberts* mentions this method of fruiting as connected with annual bearing.

In Table I under column C-1, it will be noted that successive bearing by old fruit spurs is not common, only 3.79 per cent of the fruit was borne in this manner. Yeager† also noted the fact that old spurs are irregular producers.

To further substantiate this data with respect to terminal bearing, studies were made at Council Bluffs on Winesap, Yellow Transparent, Oldenburg and Ben Davis, which were growing in the Missouri loess soil on clover sod. These varieties were compared with the same varieties growing at Ames in the black soil of the Wisconsin drift on clover sod. The trees at Council Bluffs were in the off year of bearing although they were producing a fair crop. The Ames trees were in the on year and were heavily loaded. The age of all the trees varied from 20 to 30 years.

At Council Bluffs, 409 buds were recorded and of these 22.02 per cent were borne terminally. At Ames, 424 buds were examined and of these 31.21 per cent were borne terminally. These data show the importance of terminal fruiting even on trees grown under widely different conditions of environment.

In all the studies at Council Bluffs and Ames, about 50 varieties were observed and records were made on a total of 9,960 fruiting buds, or more properly these should be called fruit growths. The average percentage on these figures are as follows:

Group A—Terminal fruiting	37.23 per cent
Group B—Lateral fruiting	31.54 per cent
Group C—Old spur fruiting	31.23 per cent

*Roberts, R. H. Wisconsin Agr. Expt. Sta. Bul. 317, July, 1920.
†Yeager, A. F. Oregon Agr. Expt. Sta. Bul. 139, August, 1916.

This summary based as it is on a large number of observations of fruiting wood grown under varying conditions, emphasizes the important part which terminal fruiting plays in fruit production.

From the observations made on the production of the buds in the lateral group it was evident that the production of these buds is dependent largely on the type of growth which they make annually. It was observed that the spurs of the lateral group B-2 would continue to make very short annual growths for as many as 10 or 15 years without producing a single fruit. Whenever the growth habit of these spurs was upset so that they put out a growth of two or three inches invariably they would produce a fruit. This is the typical behavior of lateral spurs on blue grass trees, or on trees which are low in vitality or are habitual shy bearers.

Group C buds are undoubtedly of importance in production. Roberts suggests that certain of these may bear on alternate years and contribute to annual bearing. The data show that the blue grass sod trees which are off year bearers have a rather high percentage of the C Group, 42.04 per cent.

This study suggests strongly that annual bearing depends on the production of terminal wood and upon the early fruiting of the lateral spurs. These lateral spurs in turn are dependent for their existence upon the production of strong growing terminals which produce an abundance of lateral buds. Lateral buds on the older wood produce the growth which becomes the lateral fruiting spurs. The fruit on the old spurs should be considered as thrown in for good measure because at its best fruit production on old spurs is irregular as is indicated by the fruit scars present.

Measurements were made of terminal fruiting wood on Northwestern Greening trees on cultivated and blue grass sod plots. An average of 399 measurements on the cultivated trees showed the growth to be 5.03 inches, while the average of the blue grass growth was 3.84 inches. However, this excess in growth is not all the story. The wood on the cultivated plot was plump and it had abundant lateral buds with leaves attached. The blue grass wood was thin and spindling. There were seldom lateral buds and in practically all cases the leaves with the exception of a terminal whorl dropped early in the season. A close examination of this wood shows a leaf scar with a blind bud at the base. On older wood these blind buds fail to break into growth and there is a consequent lack of lateral spurs. This evidence, in a measure, is the most logical explanation as to why trees on the sod plot are off year bearers.

Undoubtedly lack of growth and productiveness are purely a nutritional problem, the explanation of which goes back to the proposition of *Kraus and Kraybill that there is a lack of proper balance between carbohydrates and nitrates in the tree. If such is the case with the apple, then a study of the fruiting wood based on this classification should show in a measure, the condition of the tree in respect to its nutritional requirement.

It was thought that perhaps varietal difference might be con-

*Kraus, E. J. and Kraybill, H. H. Oregon Expt. Sta. Bul. 149. 1918.

nected in some way with annual and biennial bearing, and so to obtain some information as to this point, a record was made on the fruiting wood of the following varieties growing at Ames.

1. Primitive crab types 15 to 20 years old which have been reguular annual bearers: *Malus arnoldiana, M. siberica, M. niedwetzskyana, M. toringo, M. pendula, M. san-tin-tse, M. baccata, M. quini, M. pumila, M. scheideckeri.*

A Group—Terminal	45.80 per cent
B Group—Lateral	45.70 per cent
C Group—Old spur	8.60 per cent

2. Pronounced terminal bearers—annual bearers: Minkler, Willow, Black Annette, Rome Beauty.

A Group—Terminal	82.60 per cent
B Group—Lateral	14.20 per cent
C Group—Old spurs	3.30 per cent

3. A Group of varieties which are generally considered off year bearers: Oldenburg, Eastman, Yellow Transparent, Pewaukee, Russian Green Sweet, Wealthy.

A Group—Terminal	32.20 per cent
B Group—Lateral	41.10 per cent
C Group—Old spurs	26.80 per cent

4. Varieties of the Winesap group which in this section seldom bear a heavy crop two years in succession: Winesap, Arkansas (Mammoth Black Twig).

A Group—Terminal	14.00 per cent
B Group—Lateral	26.06 per cent
C Group—Old spurs	59.56 per cent

5. Standard varieties which generally bear regularly: Jonathan, Grimes, Northwestern Greening, Ben Davis, Sheriff, Roman Stem.

A Group—Terminal	41.31 per cent
B Group—Lateral	28.11 per cent
C Group—Old spurs	31.24 per cent

These data indicate that there perhaps is a varietal difference in respect to annual and biennial bearing. The annual bearers have a high percentage of the terminal fruit producing buds, while the off year bearers are low in this respect. There is a suggestion here also that the peculiarities of varietal fruit production may revert back to primitive forms of the apple. At any rate, it is a suggestion to the fruit breeder if he considers the item of annual and biennial production.

The Wealthy is generally considered an off year bearer. However, an instance was noted of a Wealthy orchard of about four

acres which had borne five successive crops. The owner had fertilized it heavily with stable manure and the production as noted was for a large part on terminal branches. This suggests that the habit of bearing can largely be controlled by promoting vigorous growth on trees of bearing age.

If there is a correlation between twig growth and productiveness, then the logical means of controlling growth is by:

1. Pruning—Rational thinning out, and heading back of old trees to increase terminal and lateral growth.
2. Soil Culture—Changing environment of tree by varying soil culture which invariably stimulates growth.
3. Fertilizing in the form of available nitrates and stable manures.
4. Top-working on hardy and vigorous growing stocks.
5. Wide planting to admit light which encourages the manufacture of carbohydrates in the leaves.
6. Spraying to protect the foliage from insects and diseases.

The observations reported herewith indicate that fruit bud studies are important as a means for explaining some of the questions involving fruit production. In particular does this apply to annual and off year bearing. The decided differences existing between the various types of fruiting wood growing under different conditions, suggest their use as a ready and practical indicator for determining the nutritional needs of the tree.

The Effect of Shading Some Horticultural Plants

By J. H. Gourley, *University of West Virginia, Morgantown, W. Va.*

ANY report upon this work is premature and is occasioned only by the fact that a change in personnel has made it desirable to close up the work to date. The project has been under way since the spring of 1917, but several interruptions and delays in carrying out important phases of the work leave it at present in a somewhat preliminary stage.

Outline of Work

The object of this work has been to study the effect of shading, or a reduction in the intensity of sunlight, upon flower bud formation in our common horticultural plants. Incidentally it has been the purpose to include other material for comparison, and the following sets of trees and plants were observed.

Group I. Shaded and unshaded trees and plants.
Group II. A pair of alternate bearing apple trees.
Group III. Apple trees ringed to induce heavy flowering.

In Group I the following material was used:

Two 12-year old Oldenburg apple trees were covered with different weights of cotton cloth in the spring of 1917 and two adjacent ones were selected as checks. These trees were under observation in 1917 and 1918.

In the spring of 1919 one Elberta and one Carman peach tree were covered with cloth shades and one of each variety was selected as a check. These were continued 1919 and 1920.

In the spring of 1919 one mature Burbank plum tree was shaded and observed for that year only.

In 1919 a rather large shade was erected and a miscellaneous lot of flowers and vegetables was planted beneath it, while a similar lot was planted in the open as a check.

Now the purpose was to secure material from these various sets of plants, which would be under controlled conditions, and by means of chemical analyses to determine some of the suposedly essential constituents in the flowering plants, and thus it was hoped to add something to our information on the balance which obtained in flowering and non-flowering trees and plants.

Chemical work was begun iin 1919, but was not undertaken serriously until 1920 when a cooperative project was effected with the Department of Agricultural Chemistry. Hence no report will be made of the chemical work, but rather some observations recorded on the behavior of the plants under the shades.

Types of Shade Used

Without reviewing the literature on the subject of shading, a brief description will be given of the type of shades used in the work. A shade octangular in shape was erected over the treated trees. The height depended upon the tree, but was sufficient to allow for the season's growth. The frame itself consisted of 2x4 pieces for uprights at the eight corners and they were tied together with 2x4 pieces in one direction and by lighter pieces in the other. A door across one side of the octagon allowed for entrance to the tree. Across the center of the top a square box effect was built to allow for ventilation. The entire frame and box were covered with cloth except a strip about a foot in width around the bottom. But outside this open strip a strip of cloth was provided which was a little wider than the open one thus allowing air to go down under the cloth and yet avoid direct sunlight or reflection from the ground entering the shade. Similarly at the top, a provision was made for the flow of air between the box effect on the top and the top proper of the enclosure. This shade has proven quite satisfactory for our purpose and can be modified according to the material used.

Effect on Air and Soil Temperature

The effect upon the trees by the shade is somewhat complicated by the fact that the temperature runs higher under the shade both in the day time and at night than in the open. During the hot-

test part of the summer there is a difference of 4 to 6 degrees and in the more moderate weather the difference is less, averaging from 2 to 4 degrees higher in the shade. Later there is a time when the records practically coincide, but when cool weather arrives the shade temperature runs slightly higher during the day and lower at night by one or two degrees.

Contrary to the air temperature (but as might be anticipated) the soil was cooler throughout the season under the shade than in the open The soil temperature was taken daily at one o'clock P. M. by means of electrical resistance thermometers, and the temperature in the shade of the Carman tree averaged 62° F., in the Elberta shade 64.5° F., while the check outside averaged 67.5° F. for the months of July and August.

Intensity of Sunlight

Several methods are in vogue for measuring the intensity of the light in such experiments. The method used here was that of recording the length of time required for photographic paper to turn a given color inside and outside the shade. The chief objection to this method is the unequal way in which the different rays of the spectrum act upon the paper, e. g. the red rays which are active in plant growth do not affect the photographic paper. However, since we wished to obtain the comparative intensity of the light in the two locations rather than measure the actual amount of light, the method seemed satisfactory for our purpose.

In 1919 the time required for the photographic paper to turn to the shade of color adopted was as follows:

In the open average for all readings	33.08 seconds
Under cheese-cloth shade (Elberta tree) average of all readings	75.42 seconds $= \frac{N}{2.28}$
Under muslin-cloth shade (Carman tree) average of all readings	225.23 seconds $= \frac{N}{6.8}$

In 1920 the same observations were made as follows:

In the open, average of all readings	10.78 seconds
Under muslin-shade, average of all readings	59.19 seconds $= \frac{N}{5.5}$
Center rather dense apple tree	39.25 seconds $= \frac{N}{3.64}$

It will be noted that there were more cloudy days included in the season of 1919 than in 1920, since it averages 3 times as long to change to the standard color in the former as in the latter year. However, the comparative intensity of sunlight between the open and shade runs much the same for the two years, being respectively

$$\frac{N}{6.8} \text{ and } \frac{N}{5.5}$$

Effect of Shade on Size of Leaves of Peach

The first noticeable and outstanding result of the shading on the peach trees was the marked difference in size of the shaded leaves. The structure and color of the leaves also varied consistently inside and outside the shade. The following figures give the average area in square inches of typical leaves selected at random about the trees. One hundred leaves and 50 leaves were measured in 1919 and 1920 respectively.

Table I

Average Area of Peach Leaves in Square Inches

	Carman sun	Carman shade	Elberta sun	Elberta shade
1919	5.29	9.32	5.55	7.71
1920	5.27	8.58	4.85	8.86

This makes an average increase in size of 69 per cent for the Carman and 59 per cent for the Elberta in the shade.

An even greater difference in size occurred with the apple trees which were under observation amounting to 224 per cent in favor of the shaded tree.

Table II

Average Area of 100 Apple Leaves in Square Inches in 1919

Date of Observation	Variety	Sun	Shade
August, 1919	Oldenburg	3.03	9.82

Similar differences were obtained with strawberry, asters, lettuce, buckwheat, geranium, and egg plant, while the snapdragon showed the opposite results.

In structure of the leaves there was also a striking difference between them. In the shaded apple tree there was one fully developed layer of palisade cells and another layer of short cells bordering on the mesophyl, which was in contrast to the unshaded leaves which showed two fully developed layers of palisade cells together with a third layer bordering on the mesophyl, which in some cases showed nearly as long cells as obtained in the first two layers. The mesophyl was usually more loose and the epidermal cells less thick in the shade leaves than in the unshaded ones. In actual thickness there was some variation, but the unshaded leaves were always much thicker than the shaded ones, amounting to a little more than 90 per cent. When the leaves from the two trees were removed from the trees the shaded leaves wilted quickly and

even on the trees exhibited a drooping habit. Some writers make considerable of the fact that shaded leaves are flat while sun leaves are quite convex, i. e. the sides are turned up. Without going into detail it may be said that the leaves of the peach, plum, and other plants showed much the same characteristics.

Effect Upon the Growth of the Plants

Among the fruit trees studied the peach was affected more than the others in the nature of the growth. In all cases the growth was greater in length, slender or willowy in nature, and less branched than where the trees were exposed to full sunlight.

Since the peach produces numerous lateral spurs or clusters of leaves at the nodes, the effect of the shading was very pronounced. The internodes were much lengthened the number of spurs and leaf clusters was reduced. This in turn had a depressing effect upon the number of flower buds which were formed. While there were spurs and leaf clusters formed on the shaded tree, they were less common than on the check tree, and usually the leaf and flower buds were subtended by a single leaf only. Very few sub-lateral branches occurred on the shaded trees while this mode of branching was common in the check.

In practically all cases of the smaller plants used in this experiment the growth was weak, but elongated, the leaves were increased materially in their area, and the root systems were greatly restricted.

Flower and Fruit Bud Formation

This phase of the work had not progressed sufficiently far to make a reliable statement. Some preliminary observation may be recorded without indicating to what extent the plants were affected by the shading alone.

The two Oldenburg apple trees which were covered with cloth shades in spring of 1917 had been blooming quite full for several preceding seasons from both spurs and lateral buds, and 1917 was no exception. In 1918 there was a light bloom on both trees and in 1919 one of the trees had 8 clusters of blossoms and the other had none, while the check trees had a 60 to 75 per cent bloom. These trees were not continued further.

The peach buds were unfortunately winter killed during the winter of 1919-20 in spite of a protective covering of hay. A few buds only wintered over on both check and shaded trees, but only those under the shade matured their fruit. Observation, however showed considerably more fruit buds formed on the check trees than on the shaded ones, as correlated with the type of growth made.

The geranium, tomato, and nasturtium plants showed in a marked way the effect of the shading as comparatively few blossoms were formed in the shade and the plants bloomed abundantly in the open.

This work is to be continued by my successor and chemical examinations are to be made in connection with the work.

The Horticultural Importance of Plant Associations

By W. H. ALDERMAN, *University Farm, St. Paul, Minnesota*

WHEN man first began to observe and study plants, the soil was considered the primary source of life and food. But as the limits of knowledge have been pushed back, this view has been somewhat modified to fit known conditions. It came about that the plant ceased being considered a passive thing, accepting only such food as the soil furnished. Instead, it was recognized as an exceedingly active and discriminating agent, selecting certain plant food materials from the air, absorbing certain other raw products from the soil and combining them through an intricate process of elaboration into suitable forms of plant food. Thus the soil came to be looked upon mainly as a storehouse of raw products rather than the active sustainer of life It became known that plants reacted to environments other than the soil. So great and so many have been these reactions that upon them has been built the science of ecology. The conception was gradually developed that plants individually, and in groups, exerted an influence over other plants. Ecologists observed definite plant successions and plant societies. Farmers have observed that certain crops do not follow other crops successfully, and that the same crop should not be grown continuously upon the same piece of land. Ragweeds come in after wheat and the cockle-bur follows corn. According to the farmer lore of some regions, beans do poorly after cabbage or buckwheat, and wheat yields better following tomatoes than it does following corn. Peas are an excellent forerunner of wheat or potatoes. The flora of limited areas changes rapidly. One species rapidly crowds out, overwhelms or displaces, another. Plants become weeds as they demonstrate their ability to displace more useful economic plants. No thoughtful man can fail to recognize that plants exercise a marked influence over each other, either through actual physical overshadowing or smothering, exhaustion of certain food materials in the soil, or through a modification of the organic composition of the soil by plant excretions or residues. Have the plant science research workers, and particularly those of the horticultural group, been sufficiently cognizant of this influence and its intimate association with projects involving questions of nutrition?

De Candolle first brought the matter to public notice when in 1832 he postulated a theory that plants, like animals, take in food or food materials and cast off, or excrete, waste substances which alter the composition of the soil. This offered an opportunity to explain the behavior of "crop sick" soils of various kinds by assuming that the plant residues contained some substances inhibiting the growth of other plants. Von Humboldt and Plenck had previously suggested that the well known grouping of certain plants was due to substances given off by them that prevented the

growth of other plants in the same area. Macaire conducted a series of experiments at the suggestion of De Candolle which seemed to indicate that toxic substances were excreted by plant roots. These findings, together with some others, gave an impetus to the toxic theory and strengthened De Candolle's conviction in its adaptability to general application. As a matter of fact, the actual evidence upon which his theory was based was somewhat scanty and the data presented by Macaire and others were not such that it would bear the close scrutiny of modern investigators. Indeed, it was subjected to so much criticism at the time, that the opinions of this pioneer plant physiologist failed to greatly impress his contemporaries.

In 1840, Liebig published his monumental work, setting forth a new theory of plant nutrition based upon amounts and proportions of mineral nutrients in the soil. So skillfully did Liebig analyze his own data and that which had been accumlating for generations, so masterfully did he marshall his evidence, and so rational and so authoritative were his conclusions, that his mineral nutrient theory completely overshadowed and displaced previous conceptions of plant nutrition. Although at one time Liebig himself supported the suggestion of toxic excretions, this phase of the question became submerged and lost to sight in the flood of attention attracted to the new theory. It is only within comparatively recent years that the toxic hypothesis has been dragged forth, dusted off, and again presented with additional evidence for the consideration of the plant scientists of the world.

In the modern conception we find two distinct situations existing. The first has to do with the influence of plants upon other plants closely associated and growing at the same time. The second is concerned with the effect of plants, or a group of plants, upon subsequent crops grown on the same soil. Since the nature of the inhibitory factor, or toxin, appears to differ widely in these two groups and, since the economic significance of the two is fairly separate and distinct, it would seem to be well to consider each by itself.

The first serious reconsideration of the plant toxin theory following De Candolle's publication, was the account by Bedford and Pickering of the Woburn Experimental Fruit Farm regarding their observations of the injurious effect of grass upon fruit trees. Under the conditions existing at the Woburn Farm, it was fairly evident that apple trees would not succeed when grown in sod, and in an effort to demonstrate the reason for this failure, Bedford and Pickering have conducted a long continued and carefully thought out series of experiments. At first it was assumed that the failure of the tree to grow was the result of plant competition which either exhausted the soil of essential food material, or depleted the moisture supply at critical periods. Tests for each condition convinced the investigators that, while such results might be operative under certain conditions, they were not major contributory causes to the failure of apples under the conditions of the experiment. By carefully checked experiments, both in the

field and in pots, they further showed that the effect of grass was not due to its influence on bacterial action, soil temperature, soil aeration, carbon dioxide concentration, alkalinity, or physical condition of the soil. Apparently there remained only the more subtile cause found in the direct influence of the grass crop upon the trees. Under conditions which seemed to include all possible precautions and to eliminate all reasonable error, it was demonstrated that, not only apple trees, but other fruit trees and forest trees as well, were subject to the inhibitory effects of grass when this crop was grown in close association with the trees. It is hardly possible, in a paper of this length, to discuss the various experiments conducted or the methods employed other than to say that, after repeated tests continued over a period of several years, it seems clear to investigators that there is given off a residue or excretion from the roots of any plant, which is toxic in its effect upon other plants, or even the same plant. The nature of this substance is not known, but it seems to be an exceedingly unstable material, which, being readily oxidized, soon changes from a toxin to a material beneficial in its effect. As far as the research has progressed, they have found no exception to the rule that all plants exercise an inhibitory effect upon their own growth and upon the growth of other closely associated plants, except in cases where they are grown on deep, well-drained soils, where the toxic materials are leached away, or oxidized rapidly enough to prevent measurable injury. There seems to be no possibility of the toxin with which they are dealing persisting in the soil for a long enough period of time to affect the succeeding crop, except beneficially on account of the readiness with which it is changed through oxidizing agencies to an innocuous or useful material.

Investigations comparable to those at the Woburn Station, but upon a far more limited scale were conducted by F. Fletcher at Surat, India and Gizeh, Egypt. In the first of two experiments conducted it was noted that plants of *Sesamum indicum*, when grown in a row at a distance of two feet from a row of millet, *Sorghum vulgare*, failed to mature and died when the plants were only a few centimeters in height. A repetition of the experiment, using maize in place of the millet, and under carefully controlled conditions, showed a similar reaction. Sasamum plants grown between two rows of maize developed only a few tiny leaves and reached only about one-twelfth the stature of normal plants. Those that had a row of maize upon one side only, developed to one-half the height of normal plants. Increasing soil moisture and plant nutrients caused an increased growth of all plants, but did not affect their relative sizes. This is the effect, Fletcher believes, of a toxic excretion, but he presents no evidence to show that it might not have been a toxic material derived as a residue from detached root hairs, or cells.

The second condition, wherein the toxic residue from plants seems to persist in the soil and affect succeeding crops deleteriously, was brought to public notice by the work of the United States Department of Agriculture in a study of the action of soil solu-

tions from good and poor soils. In this case, we are apparently dealing with a more stable substance than that described by Bedford and Pickering which persists in the soil and is not a substance so readily oxidized. In its inhibitory action it appears to affect succeeding crops of the same plant and also succeeding crops of other plants, but there seems to be a difference in the virulence of the toxic materials produced by different species. Again, without discussing methods of experimentation or the results of individual experiments, it may be said that, after carrying the investigation over a period of years, the soil chemists and physicists of the United States Bureau of Soils were convinced that there is a material, either given off as a root excretion or derived from plant residues, which is an active plant poison. There appeared to be evidence that, in some cases, this material might be considered dihydroxystearic acid, but numerous other substances were also found which might contribute to the inhibition of growth. It was found that the effect of these toxic materials could be neutralized or overcome by the addition of various agents to the soil solution. Nutrient solutions, non-nutrient salts, and non-soluble absorptive material, produce similar results when added to a soil solution containing supposedly toxic matter. It was assumed that the soluble nutrient and non-nutrient materials either acted directly upon the toxic bodies, making them non-toxic, or upon the plants, making them more or less immune and that the insoluble solids were able to absorb the injurious matter from the soil solution.

Another important series of experiments was established at the Rhode Island Agricultural Experiment Station under the direction of Dr. J. H. Wheeler in 1907, wherein a series of 16 crops were grown on uniform plots for two years, and then the entire area was planted to a single crop for the third year as an indicator or measure of the influence of the previous crops. This process is repeated every three years, the indicator being changed each time to permit a study of plant influence upon various crops. After correcting and allowing for the normal error of field experiments, the results of this test are startling and tremendously suggestive. It was found that onions exhibited a yield range from 13 to 17 bushels per acre when following such crops as cabbage, mangle beets, rutabaga, turnips and buckwheat, to a yield of from 406 to 412 bushels per acre following a crop of red top, or timothy and red top mixed. Similarly, buckwheat varied from 4 to 10 bushels per acre when preceded by millet, grass, corn or clover, to 34 bushels per acre following turnips. Alsike clover ranged from approximately 2½ tons per acre, following clover and carrots, to 4¼tons per acre, following rye and red top. These results were checked by pot experiments which varied somewhat in minor details, but in the main corroborated the work in the field. By applications of commercial fertilizers, or in some cases, by the neutralization of soil acidity through the application of lime, the crop yields in some of the low-producing combinations could be raised

to almost a normal yield, although in no case were they able to entirely counteract the effect of the preceding crop.

It will be observed from the evidence presented that at least four groups of investigators working in widely separated parts of the globe, dealing with a great range of plant species and attacking their problems with different viewpoints, have been led to a similar conclusion, namely, that plants exert a marked influence over other plants growing in the same soil. These investigators, with the exception of those in Rhode Island, who offer no explanation of the phenomena, account for this influence by the assumption that there may be incorporated into the soil an organic toxin derived as an excretion or residue from the roots of plants, which acts with inhibiting force upon the growth of closely associated plants, or upon plants of a succeeding crop generation.

What is the horticultural significance of these experiments? Do they not at least open to some question many of our preconceived ideas bearing upon plant growth and plant nutrition? Do they not raise a doubt as to the soundness of cropping systems, or lack of system, in our vegetable growing sections? Do they not raise a question as to the arrangement of many crop rotations which were originally worked out with the economic convenience of the grower in view, rather than the growth reactions of the plants under considerations? Do they not raise a question regarding the viewpoint of recent investigators who have been studying growth phenomena largely in their chemical and physiological aspects and ignoring the ecological side? If it is true in Rhode Island that onions will yield 412 bushels per acre following red top and only 13 bushels following cabbage, it is probably true elsewhere and the place of the onion in the cropping system of the truck grower deserves the most serious study. If grass affords direct injury to apple trees growing in shallow soils underlaid with an impervious stratum of subsoil, it is probably as offensive in North America as in England. The writer and others interested in plant nutrition have repeatedly pointed out the difference in reaction to fertilizers between orchards in sod and those under cultivation. It has been generally believed that this difference was due to soil exhaustion of important plant food material, or to an influence on moisture supply, but the work of Pickering is a direct challenge to such a belief. Perhaps it is not important to the grower of fruit to know whether an application of nitrate of soda to a sod orchard is beneficial because it supplies some element of plant food material heretofore lacking, or because it hastens the change of toxic substances to harmless or beneficial materials, but it is extremely important to the investigator for it strikes back to a fundamental problem in plant nutrition.

It seems clear that, in dealing with plants, we face possibly a serious question of supplying not only the elements of plant food necessary for satisfactory growth and a soil of desirable physical condition, but also of maintaining a compatible plant association if optimum growth and development are to be secured. There may be a difference of opinion as to the importance of this phase of

the work and of the extent of the influence exerted by one plant or crop over another, but all must concede that there is at least some reaction which is difficult, if not impossible, of explanation, on the basis of plant food requirements. Our knowledge of root growth and activities furnishes us with an ample mechanism for adding organic toxins to the soil. These may be incorporated into the soil solution, first, through the decomposition of dead plant roots, either of annuals or perennials; second, through the destruction of root hairs by the friction of growth expansion; third, through the sloughing off of root caps and root cap cells; and fourth, through root excretions.

Through the research, which has only in part been mentioned and very briefly reviewed by the writer, there has been presented to students and investigators of plant nutrition a viewpoint which can no longer be ignored. Since the day of Liebig we have apparently been content to accept trustingly and without question a philosophical theory of plant nutrition and stimuli based entirely upon a chemical conception of the presence and absence and proportionate amounts of so-called elements of plant food which enter into the composition of the soil solution. There are fads in science as well as in society. Charles Darwin started a fad and for well-nigh half a century naturalists were so interested in tracing lines of descent and in proving man's lowly origin, that the epoch making work of Gregor Mendel passed unnoticed for nearly two decades, or perhaps it was noticed and cast aside because it did not conform to the accepted line of thought. Is it not possible that now investigators are intent upon following certain fads in the study of plant nutrition and are ignoring more or less successfully other factors which may have a practical and fundamental bearing upon the subject? Attention has been forcibly directed to the influence of plant associations and it is incumbent upon plant scientists to determine definitely and finally if such plant reactions are vital enough and fundamental enough to be incorporated into the theory of plant nutrition, and applied to agricultural practice. If this proves to be the case, the study of organic plant toxins must be carried to the point where their origin, composition, and nature, are better understood, and methods devised whereby they may be dispersed from the soil, changed to beneficial substances, or their effects counteracted by means of an intelligent application of plant nutrients.

Report of the Committee on Research and Experimentation

By E. J. KRAUS, *Chairman, University of Wisconsin, Madison, Wis.*

IT will be recalled that at the 1920 meeting of the Society, it was deemed advisable to continue this committee, for one more year, as a test of the possible need for such an organization by the Society. During the past year there have come to the hands of the chairman seven letters of inquiry and three project outlines relative to pomological subjects, none relative to floricultural and genetical matters, and several requests for a summary or outline of olericultural investigations being conducted in various places. Professor Wellington has assembled data on this latter matter; his findings appear below After consideration of the situation in detail, the majority of the members of this committee believe that little has been accomplished by the formal existence of the committee, as such, beyond what would gladly have been undertaken by the individual members independently. We believe that every member of this Society will stand as ready to render any possible assistance to another, by acting as an individual, as he will when acting as a part of a formal committee. In fact, we believe that greater freedom will exist on the basis of the former idea.

We believe, therefore, that the committee as an organization should be dismissed.

The following is the report by Prof. Wellington.

Report on Vegetable Investigations Being Carried on by Experiment Stations and Similar Institutions

By R. WELLINGTON, *Experiment Station, Geneva, N. Y.*

THIS report was initiated first by the receipt of a letter, directed to the Chairman of the Committee on Research and Experimentation of this Society, as to which experiment stations in this country, Canada, and Europe, have instituted investigations on the use of substitutes such as green manures or cover crops and commercial fertilizers for animal manures, and as to whether any effort was being made to develop types of crops especially adapted to cultivation without manure; and, second, by a letter to the President of this Society wishing that a list of all vegetable problems being carried on in this country could be made.

The President in reply to this letter stated that such a list had been published in 1917 and 1918 annual reports of this Society and that any information that the committee might get together would only cover the same ground as that covered in the reports unless they could go into the matter in great detail. To answer the first letter, an inquiry was sent to the Office of Experiment Stations, Washington, D. C., asking for a list of those stations in this and foreign countries that were carrying on work of the character specified. On the receipt of this list, a letter was sent to the experiment stations and institutions noted, as well as to a few others, requesting the information desired. Nearly every one to whom the letter was directed, with the exception of most of the foreign investigators who may not have had time to reply, has answered the questions. Such being the case a large amount of material has been collected for presentation. To make the report of greater interest, all projects of a similar nature have been treated under the same head.

The experimental work has been grouped into eleven topics. Frequently one project spreads over at least two subjects and in that case it may be mentioned under more than one heading. In all cases the name of either the station or institution is used in connection with the project, the name of the state being used to denote the station.

Rotation and Fertilization Experiments. Since rotation and fertilization experiments are usually combined, they are treated under one head. Fertilization experiments, however, are much more numerous than rotation experiments; at least in the reports received, they stood in the ratio of approximately 3 to 1. The three states which have been carrying on the most investigational work with rotations are Rhode Island, Maryland and Pennsylvania. Lately the Massachusetts and Illinois stations have commenced work on this project and Indiana is planning to take up this type of work in the near future. Rhode Island is attacking the problem from various angles. Two three-year rotations have been in progress four and five years respectively. The results indicate that a portion of the manure may be replaced by fertilizers and that the use of fertilizers is dependent upon economic conditions. Mr. T. H. White of Maryland in a letter states, "A project started last year on a piece of poor soil where lime was used heavily in connection with nitrate of soda, acid phosphate and kainit, shows that all kinds of vegetables grew as well as, in fact better than, where manure was applied without the lime and fertilizer. Our bulletins 81, 126, 151, 199 and 215, all bear upon the substitution of fertilizers for manures and the need now is for demonstration rather than further investigation." Rhode Island is also studying the effect of early potatoes, spinach, beets and peas on a uniform second crop; and of soy beans, cow-horn turnips and mammoth clover plowed under in the fall and mammoth clover, rye and timothy plowed under in the spring on the growth of earl lettuce and beets, no stable manure being used. Pennsylvania has in progress a fertilizer rotation system on two types of

soils—early cabbage, early potatoes and tomatoes being used in both plats. The experiment is so arranged as to include "comparisons of single elements of fertilizer, two-element combinations, complete mixtures in four different amounts, varying proportions of nitrogen, phosphorus and potash, a comparison of three rates of application of stable manure with supplement of fertilizer and finally one plot which is supposed to receive a winter crop of rye and vetch after cabbage and potatoes. The last, in connection with manured plots, is expected to throw light on the relative value of cover crop and manure." Green manuring crops are to receive greater attention at this station both in and out-of-doors.

Massachuetts has been running a "Manure Economy Test" for the past three years with the object of determining the comparative value of different amounts of mixed fertilizer with and without stable manure and green manure. Cornell is conducting fertilizer tests on celery, lettuce and onions grown on muck soil and will probably start "Manure Economy Tests" next year. New Jersey has a fertilizer test on tomatoes in three different localities. Maryland is testing out the food requirements of asparagus in both plats and sunken tiles. Rhode Island is also running a fertilizer experiment on asparagus and the test is so arranged that it will be possible to determine "whether it is the sodium or the chlorine which is responsible for the well known influence of common salt on asparagus." Maryland is also carrying on fertilizer experiments with the object of inducing variation in peas, lettuce, radishes and tomatoes, and of producing dwarfer tomato plants, that is, plants with shorter internodes for growing under glass. Rotation experiments to reduce the wilt disease on peas are in progress.

The Ohio Station at Columbus has recently started a fertilizer experiment on tomatoes. Michigan is studying the proper use of fertilizer and Pennsylvania intends to start an experiment along this line. Indiana has run a fertilizer experiment for the last three years and finds that 500 pounds of 2-12-6 give the most economical returns. A special fertilizer test for sweet corn will be undertaken in 1921.

In Illinois a fertilizer experiment with truck crops was started in 1917. "This experiment involves the use of green cover crops and commercial fertilizers in various combinations in comparison with animal manures." Another and more comprehensive experiment involving twenty different treatments, including the use of cover crops, commercial fertilizers, and animal manures, on a number of different kinds of vegetables was started in 1920. A fertilizer experiment on green house lettuce and tomatoes has also been carried on for three seasons.

The Experimental Farm at Nappan, Nova Scotia, has just started some experimental work with fertilizer versus green manure. Denmark reports that a new series of fertilizer experiments testing the value of artificial fertilizers versus manure on summer cabbage, celery, tomatoes, leeks, cucumbers and early potatoes will

be started in 1922. "Green manure has at present no interest in vegetable growing here."

Fertilizers have given excellent results when used on tomatoes in Missouri. Rosa states that the fertilizer has increased yield and earliness, and further its application is cheaper and more practical for the grower of tomatoes on a large scale than manure,—250 pounds of commercial fertilizer giving approximately the same yield as 8 tons of manure.

New Brunswick in testing a 30-ton application of barnyard manure with 15 tons of manure supplemented by about 400 pounds of acid phosphate, 250 to 400 pounds of seaweed and 130 to 250 pounds of nitrate of soda (except on plats used for leguminous crops), found that manure plus fertilizer gave 2.5 per cent more beans, 3 per cent more beets, 33 per cent more carrots, 15 per cent more celery, 12 per cent more onions, and 60 per cent more tomatoes. These percentages are based on the average of different varieties of the different vegetables.

At the Virginia Truck Experiment Station the fertilizer requirements of sweet potatoes, Irish potatoes, and corn, grown in a rotation, are being studied. Fertilizer, lime, and soil requirements for various other truck crops, are also being investigated. "Extensive investigations are being conducted, looking to the substitution of commercial fertilizer and green manure for animal manures in the production of truck crops. One of these investigations was started in 1908 and has been continued since that time. Another was started in 1920 and will be continued for eight years."

Soil Composting

Rhode Island is making a comparison between soil and manure compost, and sand to which fertilizer materials in different proportions are added. Sand is used in order to obtain more definite information regarding the requirement of crops. The experiment has been run for three years with lettuce followed by cucumbers. Pennsylvania is planning to study the value of green manures in composting. Ohio (Wooster) started last winter an experiment on newly composted soil, but the results so far have been inconclusive.

Cultural Methods

Cornell has commenced a study of cultivation versus non-cultivation and the effect of each on root development. Maryland is conducting an experiment on the management of land during winter. One plat is left uncultivated, one is ridged and the third is sown to rye. All plats are planted with Irish Cobbler potatoes each season. Ohio (Wooster) is making a culture test of the following truck crops; beans, cabbage, sweet corn and tomatoes. One plat is given ordinary culture, one is irrigated and another is mulched. To date the mulched plat has had less leaf-spot on tomatoes and less anthracnose on beans. Mr. Keil believes the reasons for this decrease in disease is due to the washing of the spores below the mulch, where they are retained instead of being splashed back

upon healthy portions of the plants, as is usually the case in clean cultivated ground. Irrigation experiments are also being carried on by Pennsylvania and at Odense, Denmark.

Missouri is studying methods of transplanting vegetables, the "hardiness process" in vegetable plants and cultural investigations with Irish potatoes. Nebraska, too, is conducting cultural experiments on the potato both in and out-of-doors. In the greenhouse studies are made on the following factors: temperature, soil moisture, soil texture and structure, time of irrigation, wind, humidity and sunlight. Out-of-doors various cultural practices, including mulching and irrigation, are being studied in their relation to seed quality of several varieties.

The North Carolina Department of Agriculture is studying cultural practices with both the Irish and sweet potato; points being observed with the former are (a) width of rows, (b) distance apart in the rows, (c) freshly cut or stored cut seed, (d) effect of sprouting on yield and (e) cut versus uncut seed; and with the latter, (a) comparative value of slips versus vine cuttings as regards productivity, (b) effect of ridging on productivity and type of potatoes, and (c) effect of vine cutting on yield.

The Truck Station at Norfolk, Virginia is carrying on cultural investigations and the Danish Experiment Station at Odense is experimenting on the distance of planting cabbage, celery, red beets, beans and peas.

Pruning, Training and Suckering

Cornell has experiments under way in the pruning and training of cucumbers and tomatoes, and suckering of corn.

Study of Plant Variations, Habits and Adaptations

Pennsylvania has been conducting experiments on the respective value of large, medium and small sized asparagus crowns; three sizes of asparagus seed; and seed from different parts of the asparagus plant. Ohio (Wooster) has just started an experiment comparing the subsequent growth of large and small sized asparagus plants. Rhode Island has a project which has been running intermittently for twenty-five years on the feeding powers of different vegetables and their requirements for the fertilizer elements. Pennsylvania is contemplating the study of the effect of missing plants, extent of cross feeding between plats, reduction of variability of plants and consequently the use of smaller plats, and the behavior of plants grown under varied soil and climatic conditions. This state is also preparing to make an extensive study of green manuring crops with respect to rate of growth and methods of hastening growth, hardiness, resistance to shade, seed production, and companion cropping with vegetables. An experiment on the control of club-root on cabbage by the use of fertilizer and lime is under way. Maryland is making a study of cool season crops as grown in mountainous sections of the state and is crossing tomatoes, celery, peas and cabbage with the object of securing new varieties better adapted to Maryland conditions. The value

of islands and points in the Bay or Ocean for growing cabbage seed is being determined, and tests of northern versus home grown sweet corn for both seed and canning purposes are being continued. Study of dormancy in the onion started in West Virginia will be continued in Maryland. Texas in co-operation with the United States Department of Agriculture is carrying on experiments to determine the value of potato seed produced in various sections of the country. Indiana is testing on an extensive scale the value of home grown sweet corn seed versus Ohio, Illinois and Connecticut seed; of home grown versus northern grown Irish Cobbler potato seed. Iowa has been carrying on for three years a sweet corn investigation with "various strains of Evergreen sweet corn to determine the influence of environment, with special reference to the sugar, starch and crude fibre content and their quality for canning. Iowa as well as Nebraska and North Carolina are also conducting seed piece studies of the potato.

Breeding and Selection

Certain phases of selection have been mentioned in connection with other projects and such cases will not be repeated. As might be expected this branch of investigational work is equal to fertilizer work in interest. Massachusetts is making progress in purifying strains of vegetables and has given especial attention to celery. Cornell is making strain tests of celery, lettuce, onions, tomatoes and cabbage. Geneva has produced a few types of forcing melons and a new variety of tomato by crossing and selection. Pennsylvania has been trying to secure a rust resistant asparagus, but will drop this project owing to the advent of the Martha Washington variety. New Jersey is making selections within the variety Howling Mob sweet corn and Maryland as already mentioned, is carrying on selection and breeding experiments with numerous vegetables. The Wooster Ohio Station is selecting strains of Stowell Evergreen corn for canning houses by the ear-row test. Selections are also being made for a disease resistant navy or field bean, a better type of May King lettuce, spinach adapted to greenhouse conditions, and wilt resistant Bonny Best tomato strains. Mr. Keil in remarks on the two strains of Grand Rapids lettuce produced by his Station says, "The 'Dark Green' strain shows a marked advantage over the 'Light Green' strain for the early winter crop, in which the lesser amount of sunshine is a limiting factor. The dark green leaves with greater development of chlorophyll make a decided gain in growth over the light green plants of the other strain." Michigan is selecting strains of potatoes by the use of hill and tuber-unit methods, and developing strains of tomatoes by crossing and selection. This station is also selecting improved strains of onions. Kentucky is selecting disease resistant strains of white potatoes and lettuce and wilt resistant tomatoes. Indiana, like Ohio, is making selections of sweet corn by the ear-row test. It is also trying to improve tomatoes for canning purposes, by making individual plant selections. The improved seed is given to the canners and the canners distribute

it the following year to growers. Illinois like Maryland has isolated wilt resistant strains of tomatoes and Missouri is selecting disease resistant strains for its conditions.

Minnesota has extensive breeding and selection experiments under way. Excellent progress has been made in the isolation of desirable strains of peas, beans and squash by starting with individual plants. Selection of strains within tomatoes has given uncertain results. First generation tomatoes, however, have made a favorable showing compared with their parents. Hill selection experiments of potatoes proved a failure probably on account of diseases. Cucumber crosses have been produced by crossing English and American varieties and a few selected types have developed fruit without fertilization.

In Denmark, breeding experiments are being carried on with winter cabbage, red beets and potatoes and in the selection of frost resistant red cabbage.

The Ontario Agricultural College since 1913 and 1914 has done a large amount of breeding work with vegetables. Improvement work is being carried on with celery, onions, beans, greenhouse cucumbers, spinach and lettuce. The object in breeding the last two crops has been to develop long-standing types. Promising strains of Paris Golden celery have been distributed and new strains of onions, lettuce and greenhouse cucumbers will probably be introduced in another year or two. Other crops worked with are tomato, carrot, parsnip, sweet corn, cabbage and beets. Work has been or will be discontinued on all these crops except the last two. A greenhouse cucumber has been developed that is similar to the White Spine in length, dark green in color and sets fruit freely without pollination. Selection of disease resistant beans is also in progress. No results were obtained in the improvement of Detroit Dark Red beets, Glory of Enkhuizen cabbage, Golden Bantam corn, carrots and in and out-of-door tomatoes.

Missouri in addition to selecting wilt resistant tomatoes is attempting to develop a good early market tomato of the Bonny Best type and another of the June Pink type. Nebraska has isolated high, medium and low yielding tuber line strains of the white potato which have retained their relative positions for the last three years. The North Carolina Department of Agriculture is also making selections within both the Irish and sweet potato.

Iowa like Wisconsin has developed varieties of cabbage that are resistant to yellows, but so far the strains have not been altogether satisfactory from the standpoint of good horticultural types and earliness.

Pollination Studies

Cornell and Maryland are conducting experiments on the pollination of tomatoes. The Maryland work is based on the selection of strains which set fruit without hand pollination.

Use of Electricity

Kentucky was the only station that reported on the use of electricity to stimulate plant growth. Vegetables used in this experiment are sweet corn, snap beans, tobacco, tomatoes and Irish potatoes.

Cost of Production Studies

A number of stations have taken up cost of production studies. Cornell in co-operation with the Department of Farm Management is making a survey of cost of production and cultural practices on canning crops. Maryland, New Jersey and Indiana are also making a study of the cost of growing tomatoes. A feature of the Indiana work is a comparative test of hot bed, cold frame and open bed grown plants, the hot bed plants being transplanted one and two times. One transplanting so far has proved to be the most economical. Texas is also studying the cost of producing plants for transplanting. Next season Maryland is contemplating the carrying out of a project on the harvesting and marketing of cantaloupes.

Degeneracy of White Potatoes and Disease Studies

Degeneracy of white potatoes is probably the most important and vital of any problem now facing the vegetable industry and wherever the potato is grown more or less work is being done along this line. States giving this subject special attention are: Nebraska, Minnesota, Wisconsin, Iowa, Michigan, New York, Indiana, Maine, Maryland, Virginia, Kentucky, North Carolina, Texas, Arkansas, Oklahoma, Florida, Louisiana, Montana, Washington, Colorado and California. Many stations, as mentioned under breeding and selection, are selecting disease resistant strains and a few are carrying on spraying experiments to control disease. The Norfolk Station is devoting considerable time to the control of diseases of spinach, sweet potatoes, Irish potatoes, egg plants, parsley and other truck crops, and to physiological studies of susceptibility of spinach and other plants to the mosaic disease.

Storage Investigations

Both the Norfolk Station and the North Carolina Department of Agriculture are conducting sweet potato storage investigations.

Test of Varieties

Variety testing is carried on extensively by a few stations and in others it is simply conducted as a side issue of other problems. Greater interest is shown in making selections within varieties.

Conclusion

This report may be criticised for not taking up methods of procedure more in detail; however, it is obvious that if the subject were attacked in this manner the report would be too long for publication. All that has been attempted is to point out the principal

work that is under way. It will be noted that a few stations are making excellent headway, but unfortunately the majority of them are not giving vegetable investigational work sufficient attention. The writer would suggest that at the future meetings of this Society methods of procedure for various problems be taken up for discussion. No attempt should of course be made to destroy either initiative or individuality of the respective workers, yet if certain problems were taken up at the same time in different localities, varying in soil and climatic conditions, and worked out along definite and similar lines, certain fundamental conclusions could undoubtedly be obtained that are not now obtainable.

It is to be regretted that this report is not more complete. This is due largely to the fact that many institutions that might have supplied information were either not approached or failed to reply. The reason for not writing to all the stations and investigational institutions, as already noted, was that the scope of the report when started was restricted mainly to a limited field. It is hoped that at a later date a more comprehensive and exhaustive report can be prepared.

Report of the Committee on Botanical Abstracts

By E. J. Kraus, *University of Wisconsin, Madison, Wis.*

BOTANICAL Abstracts is now a firmly established journal, though at the present time it is not operating without a deficit. Such deficit at the present time amounts to more than two thousand dollars, in spite of the fact that most of the expenses of the office of the biblographic committee were paid by Dean Mann of the New York State College of Agriculture, and a grant of three thousand dollars was secured from the National Research Council. The most imperative need of Botanical Abstracts is a guarantee of support either by a special endowment or by some institution. This matter is in the hands of a special committee, is being handled aggressively, and there is every reason to believe that substantial assistance will be secured in the very near future.

It is highly desirable to increase the number of subscribers to the Journal, and if possible to decrease the subscription price. The whole matter of investigating the question of cheaper publication and general management of Botanical Abstracts, has been placed in the hands of a special committee.

It is unnecessary to dwell on the details relative to the material finally published, since that whole problem is left for the several sectional editors to deal with as seems best. It remains simply to state that every possible effort is being made to make every section of real service, and the real responsibility for this rests with the individual collaborators. Additional information relative to the preparation of abstracts will be sent to them in the near future.

Report of the National Research Council Committee

By U. P. Hedrick, *Chairman, Experiment Station, Geneva, N. Y.*

YOUR Committee, composed of E. C. Auchter, S. W. Fletcher, C. A. McCue, W. H. Chandler and U. P. Hedrick, the last named being chairman, met with Dr. C. E. McClung, Chairman of the Division of Biology and Agriculture on December 4, 1920. By invitation Dr. B. T. Galloway, of the United States Department of Agriculture attended the meeting. The purpose of this meeting was to find out what this Society could do through the National Research Council. The following is a brief report of the meeting.

The chairman of the committee had presented at the annual meeting of the division on May 6, 1920, one of the needs of horticulture, that of the establishment of arboreal plantings of species of cultivated fruits and nuts in the different parts of the United States. At that meeting the division discussed the possibility of establishing such plantings and came to the conclusion that the plan was quite worth while, but that in the meantime there should be some means whereby workers in horticulture and botany could be given information through some publication or another as to where these species of cultivated plants might be found. This matter with the conclusion of the division was now brought before the committee from the Society for Horticultural Science.

All the members of the committee present agreed that it would be most desirable to try to establish such plantations, and in doing so to work through the National Research Council. The members of the committee believed that there should be at least eight or ten such arboreal plantings in the United States and Canada. The members of the Committee agreed also that as a preliminary to the establishment of these plantings a survey should be made, the results of which should be published. Dr. McClung thought it possible that the National Research Council might publish this preliminary survey with the expectation that copies would be sold to pay for publication. Dr. McClung agreed to take the matter up with the proper authorities in the Research Council. It was agreed by the members of the committee that for the present the survey should be limited to hardy fruits and nuts.

The question then arose as to who could make the survey. Dr. Galloway, upon being asked whether it could be done in the Department of Agriculture, stated that he would look over the field and consider the possibility of making the survey through his office. Upon motion the whole matter of the survey was left in the hands of the chairman of the committee with power to act. It was agreed that the next step following the survey and the publication of its results would be to start some propaganda work with regard to these arboreal gardens. The work of your committee

for the next year will consist largely in making this survey and creating interest in the proposed aboreal plantings.

In order to bring the matter of aboreal gardens before this Society, Dr. Galloway agreed to write a letter setting forth his views as to what the gardens should be, for presentation to the Society for Horticultural Science at this meeting. The following is Dr. Galloway's letter concerning the establishment of collections of growing arboreal economic plants to be used in breeding work and arboreal crop improvement.

"SUGGESTED NAMES FOR SUCH COLLECTIONS

1. Arboreal Plant Gardens.
2. Economic Arboreal Gardens.
3. Gardens of Economic Trees and Shrubs.

"GENERAL STATEMENT

"Trees, shrubs, vines, and other woody plants have furnished food, shelter, and clothing for man from time immemorial. They have also furnished the means of improving man's surroundings, beautifying his home, and making his life more worth while. Trees, shrubs, and vines will become increasingly important as population grows more dense and the complexities of life increase.

"Considerable areas of land in this country not now devoted to ordinary crops could be made useful by tree cropping. There is much to be done in the matter of increasing our tree food supply, our diminishing stocks of timber, supplies of raw material for clothing and shelter, and the beautification of our surroundings through securing new types of arboreal plants by means of breeding.

"There is need for collections of carefully selected species and varieties of economic trees, shrubs, and vines for the purpose of utilizing them in breeding work.

"Such material, useful for our temperate regions, is now very limited. Moreover, it is widely scattered. A great deal of it, together with many new species and varieties of hitherto untried species and varieties, could be brought together and so grown that they would be available for plant breeders everywhere. Such places would be in the nature of out-of-doors laboratories furnishing living material to work with. Plant breeders would be free to come to these gardens, do their work, and take the resultant material away with them, to be grown or tested where it would most likely succeed. These collections of species and varieties, therefore, would become a constant source of raw material for the development of new trees and other arboreal crops, economic fruits, nuts, and related trees, economic timber species, etc.

"COLLECTIONS MAY BE REGIONAL OR VARIED

"The arboreal breeding gardens are not to be regarded as arboretums. They are working collections of woody plants brought together for a specific purpose. They may be located with due re-

gard to regional needs and requirements and the assemblage of growing species and varieties may and doubtless should vary with each garden. Thus it may be desirable to have one garden predominating with nut tree species and varieties that may serve for comprehensive breeding work. Another might predominate in Pyrus, Malus, Prunus, and related genera. The beginnings of several of these arboreal gardens are already in existence—at the New York State Experiment Station, Geneva; at Bell Station, Maryland, where the Office of Horticulture and Pomology of the United States Department of Agriculture is conducting breeding work through Dr. Walter Van Fleet; at Chico, California, where the Office of Foreign Seed and Plant Introduction has extensive plantings of many new and rare plant immigrants; and at Mandan, North Dakota, where the Office of Dry Land Agriculture has extensive horticultural and arboricultural plantings particularly adapted to the cold northwest regions of this country. There are also fine collections at Niles, California, brought together by the late John Rock.

"Means of Support

"It is probable that several of these breeding gardens may be supported by federal or state funds or both combined. Others might be supported by modest endowments from private sources. There should probably be five or possibly seven of these gardens, so placed as to cover the general range of arboreal economic plants in this country.

"Necessary Facilities and Equipment

"A suitable tract of good, arable land, consisting possibly of seventy-five to a hundred acres, would be required; also, one or two modest cottages for the resident director and an assistant or two, a small greenhouse, and suitable propagating frames. Such gardens might after establishment be kept going on a modest sum of five to eight thousand dollars a year.

"Need for Definite Plans and Policies

"To successfully carry through such a project as here outlined would require careful thought and work on the part of the Society for Horticultural Science. If the project is thought worthy of support, the work might be taken in hand by a small committee, such a committee being given power to develop definite plans and policies looking toward the establishment of the gardens and the bringing of all of them in full harmony and co-operation to the end of attaining the objects in view. B. T. Galloway."

At the request of the Chairman of this Committee Dr. Galloway has proposed to him the following project for making a survey of living arboreal plant material available for breeding purposes at arboretums and other places in the United States and Canada. The following is the proposed project.

PROPOSED PROJECT

Name: Reconnaissance survey of living arboreal plant material available for breeding purposes at arboretums and other places in the United States and Canada.

Object: To assemble and prepare for publication in the form of a report brief descriptions and suggestive notes and explanations of the more important economic arboreal plants now growing in the principal collections of the United States and Canada, including the Arnold Arboretum; the collections at the New York Experiment Station, Geneva; the public parks of Rochester, New York; the Ottawa station and branch stations throughout western Canada; the collections of the United States Department of Agriculture at Mandan, North Dakota, and Chico, California; and other growing collections, nationl and state, where cooperation may be secured. To prepare the descriptive notes and suggestions in such fashion that they will furnish plant breeders and horticultural workers with specific information as to the location of the living material for study, the age and size of the plants, the blooming and fruiting periods, special characteristics such as disease and insect resistance, cold resistance, drought resistance, etc.

Procedure: Secure by correspondence and conferences with official horticulturists, plant breeders and others, suggestions and advice as to the general scope of the survey. It will be necessary to determine and decide fairly definitely in advance on the principal genera to be included. Necessarily *all* arboreal plants can not and need not be included. Utilize as far as practicable the large amount of data now available among the records of the United States Department of Agriculture, state experiment stations, and elsewhere, and secure through cooperation with officials in charge of collections additional data that may be useful. Prepare for publication as a bulletin of the United States Department of Agriculture or a special report issued by the National Research Council.

Your committee desires either approval or disapproval of its action at this meeting and wishes the members to present such suggestions or criticisms as they may desire to make.

A New Factor in the Determination of the Hardiness of the Apple

By A. L. BAKKE, W. A. RADSPINNER AND T. J. MANEY, *Iowa State College, Ames, Iowa.*

AS the apple varieties grown at the present time in the upper Mississippi Valley do not possess the quality demanded in the apple industry, an attempt is being made by S. A. Beach and his associates in the pomology section of the Iowa Experiment Station

NOTE: Address was not received soon enough to be placed in its proper position in the body of the report.

to produce by breeding, varieties of high quality coupled with hardiness, or ability to withstand the climatic environment. In this work they have originated during the past fifteen years, nearly 30,000 apple seedlings in addition to the several hundred which were produced by the earlier workers at this station. The outstanding importance of the hardiness problem in apple growing has long been recognized by the horticulturists of this region. It is not necessary before this audience to point out the long drawn out, tedious process involved in growing apple trees to a bearing age. Yet in breeding apples it is necessary to produce large numbers and then to exercise rigid selection to secure the best.

Any method which would make it possible to eliminate a portion of the orchard trials, even 25 per cent, would be of extreme value. Beach has always recognized this point and has carried on a considerable amount of unpublished preliminary work along this line. In 1911, Allen[1] began under his direction, a series of experiments to correlate hardiness with structure and composition, the results of which were published in 1915.

They found that the water content and the time at which the season's growth attains its maturity are two factors, which at least enter into the determination of hardiness.

About this time Fitting[2] published his results upon the osmotic pressure in the cell sap of a large number of desert plants. Although Cavara[3] had performed cyroscopic tests as early as 1905, the data were not utilized. Fitting's plasmolytic studies showed that there was a variation in the concentration of the cell sap even when edaphic characters were the only ones considered. Since that time, there have been investigations by Ohlweiler[4], Chandler[5], Dixon[6], Harris, Lawrence and Gortner[7]. Harris and Popenoe[8]

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[1]Beach, S. A. and F. W. Allen, Jr. Hardiness in the apple as correlated with structure and composition. Iowa Agr. Exp. Sta. Research Bull. *21*. 1915.

[2]Fitting, H. Die Wasserversorgung und die osmotischen druckverhaltnisse der Wüstenflanzen. Zietschr. Bot. *3*:209.275. 1911. In the connection see Livingston, B. E. The relation of the osmotic pressure of the cell sap in plants to arid habitats. Plant World *14*:153-164. 1911.

[3]Cavara, F. Risultati di una serie die ricerche crioscopische sui vegetali. Cont. Biol. Veg. R. Inst. Bot. Palermo. *4*:41-81. 1905.

[4]Ohlweiler, W. W. The relation between the density of cell saps and the freezing point of leaves. Ann. Rep't. Mo. Bot. Gard. *23*:101-131. 1912.

[5]Chandler, W. H. The killing of plant tissue by low temperature. Mo. Agric. Exp. Sta. Res. Bull. *8*. 1913.

[6]Dixon, H. H. Transpiration and the ascent of sap in plants. London, 1914. See pages 139-200.

[7]Harris, J. Arthur, J. V. Lawrence and R. A. Gortner. On the osmotic pressure of the juices of desert plants. Science N. S. *41*:656-658. 1915. Cryoscopic constants of expressed vegetable saps as related to local environmental conditions in the Arizona deserts. Physiol. Res. *2*:1-49. 1916. See also Harris, J. Arthur. Physical chemistry in the service of phytogeography. Science N. S. *46*:25-30. 1917.

[8]Harris, J. Arthur and Wilson Popenoe. Freezing point lowering of the leaf sap of the horticultural types of *Persea Americana*. Jour. Agric. Res. *7*:261-268. 1916.

have gone so far as to indicate possibilities of differentiating relative hardiness of different types of avacados (*Persea Americana*) in that the variety characterized by having the slightest freezing point lowering of its extracted sap is the one which is the least capable of withstanding cold. Johnson[9], working with two peach varieties, has correlated hardiness with moisture content, the hardier variety having the lower percentage of water.

In the winter of 1919-20, the writers undertook an investigation of methods of determining hardiness in the apple with respect to low temperatures. This was taken up as a phase of the apple breeding project of the Iowa Experiment Station already referred to. From the results furnished us by the above investigators it is apparent that the freezing point lowering ($\triangle$) difference is not in itself sufficient to give results which would be applicable as a measure of the respective differences in hardiness of various varieties. With this in mind, it was deemed advisable to make a series of tests at five different times of the year, of the depression of the freezing point ($\triangle$), the water content, ash content and the hydrogen ion concentration. In this presentation, the freezing point lowering, the per cent moisture, per cent ash and the hardiness factor are given in each of the tables.

The hydrogen ion concentration, according to our tests, using the colorimetric method, has a PH value of 5.4 throughout, and is therefore given no further consideration. The periods chosen according to the order appearing in this publication are (1) dormant, (2) bud swelling, (3) blossoming, (4) summer growth, (5) wood ripening. The material used in the present study consisted of twigs representing the current year's growth of apple trees of eighteen of the common commercial varieties grown upon different stocks under conditions which at their best were only approximately uniform. In the orchard from which the samples were taken there were generally three trees of the same variety adjoining each other. In all cases the twigs were taken from all the trees from different parts, ground and thoroughly mixed before the sap was extracted. Tests were also made of fourteen different varieties of two year old nursery trees taken from the Mount Arbor Nurseries at Shenandoah, Iowa, on August 12, 1920.

It was recognized of course that it would be perferable to work with nursery stock, but if fifteen year old material would give data that indicated correlations between physical and chemical constituents, it would be an easy matter to consider the nursery material later. Throughout the entire season, twig cuttings were taken from the same trees, except that in the last table the data were secured from the two year nursery trees as previously mentioned.

In ascertaining the lowering of the freezing point, the usual Beckman apparatus was used. The material was first ground in a food chopper as soon as it was brought into the laboratory. If delay was necesssary, the twigs were kept in a cool refrigerator.

[9]Johnson, Earl S. An index of hardiness in peach buds. Amer. Jour. Bot. *6*:373-379. 1919.

As soon as the material was ground, it was immediately frozen by the aid of a brine mixture and kept in that condition until extracted. A hydraulic press was employed to remove the sap. Before the pressure was removed a force of 350 kilograms to the square centimeter was applied in all cases.

To obtain the moisture content and amount of ash, samples were taken, after which they were immediately placed in an oven at a temperature of 100° C. until a uniform weight was secured; the amount of ash was obtained by the use of an electric muffle furnace. Calculations were made on the basis of water-free material.

In the accompanying tables in all cases, the date of collecting the variety, the freezing point lowering, the per cent moisture, and the hardiness factor, are given. When the work was first started, the purpose was to make note of the depression of the freezing point of the sap of the common commercial varieties of apple trees throughout the year at five different periods, and the hardiness factor was not determined until after the results from the two year old nursery stock had been derived. It is found by taking the square root of the freezing point lowering and multiplying this number by the square of the per cent moisture and later dividing the product by a hundred so that a whole number with two digits instead of four is formed. Although the method is the same throughout, and may be regarded as somewhat arbitrary, yet the authors feel that certain lines must be drawn. As the reasons for the mathematical calculations are clearer and more easily comprehended from data submitted in Table VI, a full explanation will be reserved until then.

TABLE I

Dormant Period.

Date	Variety	Freezing point lowering (Δ)	Per cent moisture	Per cent ash (dry)	Hardiness factor
1920					
2-14	Hibernal	1.80	42.43	3.42	24.15
2-16	Oldenburg	1.53	45.64	3.88	25.71
1-21	Wealthy	2.10	45.04	4.19	29.38
2-16	Malinda	1.69	44.63	2.55	25.90
2-6	Yellow Transparent	1.70	46.32	4.08	27.96
2-6	Fameuse	1.83	46.09	3.02	28.69
2-10	Walbridge	2.51	42.36	3.55	28.43
2-6	McIntosh	1.82	46.82	3.48	29.58
2-14	Northwestern Greening	1.76	42.49	3.58	23.95
2-6	Salome	1.72	47.38	3.47	29.45
2-6	Red Astrachan	2.07	47.30	3.68	32.18
2-6	Roman Stem	1.70	47.91	3.44	29.88
2-6	Willow Twig	1.93	46.51	3.80	30.08
1-21	Jonathan	2.61	43.52	3.75	30.59
2-10	Winesap	....	47.58	4.54	.....
2-10	Grimes	1.56	48.23	4.04	29.08
2-10	Ben Davis	1.81	47.76	4.51	28.18

In the presentation of the data, consideration of the freezing point lowering, percentage or moisture, ash content and hardiness factor, are made of the eighteen varieties (only seventeen in the dormant period) for the dormant, bud swelling, blossoming, summer growth, and wood ripening periods. The data for each, with accompanying explanation, are tendered in the order given: explanation, discussion, and description of the Shenandoah, Iowa Nursery material immediately follow.

During the dormant period, the depression of the freezing point ranges from 1.53 for Oldenburg, a hardy variety, to 2.61 for Jonathan, a variety which is not fully hardy in Central Iowa. It is also found that Walbridge has a depression of 2.51. Then again, Grimes and Ben Davis varicties, the least hardy of the entire series have depressions respectively of 1.56 and 1.81. No substantiations of the theory that slight depression of freezing point is correlated with lack of hardiness is given by the results.

The moisture content ranges in the different varieties from 42.36 for Walbridge to 48.23 for Grimes. Ben Davis has a moisture content greater than Yellow Transparent which in turn is only slightly higher than Oldenburg.

In the case of the ash content during the dormant period, there is considerable difference between the hardier varieties Hibernal, Malinda and Fameuse, as compared with the less hardy varieties Ben Davis, Grimes and Winesap. But other hardy varieties as Wealthy and Yellow Transparent do not give consistent results as compared with other less hardy kinds as Jonathan and Roman Stem. The averages in groups of four, passing down the list are respectively, 3.51, 3.53, 3.54, 4.03 with Ben Davis left alone to start the next lower group at 4.51. From this point of view the ash data are evidently of some significance.

Considering the fact that the hardiness factor is derived from the freezing point lowering and the per cent moisture, it would hardly be expected that the results would be even suggestive. Considering the variety at the head of the list and the one at the end, there is a rather marked difference, Northwestern Greening has the lowest factor, 23.95 while Red Astrachan has the highest, namely, 32.18.

In the bud swelling periods, where the samples were taken from April 27th until May 3rd, the freezing point lowering is much less throughout, going as low as 0.95 (Ben Davis) and not exceeding 1.36 (Grimes) with no apparent difference in varieties known as hardy and those recognized as being tender. The water content has risen materially in all cases. The hardiness factors extend through a wider range than in the dormant period. Walbridge, with a factor of 23.70 is the lowest, while Red Astrachan is the highest (factor 35.32). The last named variety was the highest in its hardiness rating at the dormant period, (32.18).

After scanning the data on per cent of ash, it is seen that passing down the list the averages in groups of four are respectively, 3.625, 3.670, 3.945, 4.040 with a final group of two averaging 4.435.

TABLE II

Bud-Swelling Period.

Date	Variety	Freezing point lowering (△)	Per cent moisture	Per cent ash (dry)	Hardiness factor
1920					
4-27	Hibernal	1.07	48.65	3.42	24.48
5-3	Oldenburg	1.08	53.31	3.49	29.50
4-30	Malinda	1.01	51.66	2.97	26.22
4-30	Yellow Transparent	1.01	54.17	4.62	29.47
4-30	Fameuse	1.26	52.10	3.60	30.49
4-30	Walbridge	1.01	48.57	4.17	23.70
5-3	McIntosh	0.98	52.33	3.51	27.10
5-3	Northwestern Greening	1.15	50.52	3.40	27.36
4-30	Salome	1.02	57.58	3.99	33.50
4-30	Red Astrachan	1.07	58.45	4.42	35.32
4-30	Roman Stem	1.04	54.86	3.85	30.48
5-3	Pewaukee	1.11	52.03	3.52	28.50
4-30	Willow Twig	1.06	55.23	4.16	31.40
4-30	Jonathan	1.20	52.00	4.43	29.62
5-3	Mann	1.03	55.44	3.72	31.19
4-30	Winesap	1.05	50.57	3.85	28.17
4-30	Grimes	1.30	49.54	4.63	28.00
4-30	Ben Davis	0.95	51.94	4.24	26.30

The varieties are not all the same as were given in Table I. Again the results are somewhat significant.

TABLE III

Blossoming Period.

Date	Variety	Freezing point lowering (△)	Per cent moisture	Per cent ash (dry)	Hardiness factor
1920					
5-21	Hibernal	1.34	.....	3.01	.....
5-18	Oldenburg	1.20	65.53	4.82	44.19
5-21	Malinda	1.43	62.15	3.58	46.18
5-18	Yellow Transparent	1.24	65.57	4.68	47.85
5-18	Fameuse	1.28	67.04	4.26	50.80
5-25	Walbridge	1.37	61.33	4.71	43.97
5-18	McIntosh	1.19	61.87	4.56	41.73
5-25	Northwestern Greening	1.36	64.35	4.72	48.36
5-21	Salome	1.21	65.70	4.66	47.49
5-18	Red Astrachan	1.23	65.79	4.69	48.06
5-21	Roman Stem	1.54	64.33	4.86	51.34
5-21	Pewaukee	1.28	63.50	4.53	45.58
5-21	Willow Twig	1.34	65.72	4.55	49.93
5-25	Jonathan	1.53	62.62	5.60	48.48
5-18	Mann	1.40	62.48	3.99	46.22
5-25	Winesap	1.52	64.48	5.77	51.29
5-25	Grimes	1.48	65.22	5.48	51.70
5-25	Ben Davis	1.60	63.20	6.33	50.58

At the time of blossoming the depression of the freezing point is higher than for the previous period, the per cent moisture, and the ash, with one exception, are also greater. Accordingly, it is to be expected that the hardiness factor would be of greater magnitude. At this time $\triangle$ ranges from 1.19 (McIntosh) to 1.60 (Ben Davis). The moisture variation between the different varieties is slight, extending from 61.33 for Walbridge to 67.04 for Fameuse. In several cases it is noticeable that where there is a low depression, the water content is high; Oldenburg $\triangle$ 1.20, moisture content 65.53; Ben Davis $\triangle$ 1.60, moisture content 63.20; other cases might also be cited. Between the varieties Hibernal and Ben Davis there is a range in the ash content of 3.32 per cent. The variety Mann regarded usually as being in the Jonathan-Winesap category with respect to hardiness, has an ash content of 3.99 per cent. For this period there is recorded, so far at least, the greatest range in the hardiness factor, being 44.19 for Oldenburg and 51.70 for Grimes. Considering the fact that Oldenburg, Malinda and Yellow Transparent have a hardiness factor less than 50, and that Winesap, Grimes, and Ben Davis have a factor in excess of 50, it is possible to list the different varieties into three distinct classes; the hardy, the medium hardy, and the non-hardy. The first class would include the varieties, Oldenburg, Malinda, Walbridge, McIntosh and Hibernal, although it was not possible to use the figures for the Hibernal. The Yellow Transparent and Fameuse are perhaps rated a little too high. Roman Stem, Willow Twig, Jonathan, Winesap, Grimes and Ben Davis would go in the

TABLE IV

Summer-Growth Period.

Date	Variety	Freezing point lowering ($\triangle$)	Per cent moisture	Per cent ash (dry)	Hardiness factor
1920					
6-28	Hibernal	2.06	58.98	4.30	49.94
7-2	Oldenburg	1.92	60.50	5.07	50.70
7-2	Wealthy	2 17	61.11	5.09	54.99
6-28	Malinda	1.99	57.40	4.48	46.50
6-28	Yellow Transparent	1.88	61.49	4.72	51.82
7-8	Fameuse	2.13	57.94	4.06	48.98
6-28	Walbridge	2.08	58.83	4.50	49.88
7-8	McIntosh	2.06	57.76	3.88	47.87
7-8	Northwestern Greening	2.06	57.44	4.11	47.36
7-8	Salome	2.11	58.15	4.44	49.06
7-2	Red Astrachan	1.97	60.82	4.69	51.93
6-28	Roman Stem	2.08	58.12	4.25	48.69
7-8	Willow Twig	2.19	57.27	4.10	48.54
7-2	Jonathan	2.05	58.77	4.69	49.43
7-8	Mann	2.13	58.46	4.50	49.84
7-2	Winesap	1.72	58.67	4.31	45.14
7-2	Grimes	2.01	58.95	4.99	49.29
6-28	Ben Davis	2.12	59.44	4.95	51.46

less hardy class, while the remaining varieties naturally would be placed in intermediate positions between the hardy and the less hardy.

Passing down the list as before and noting the averages as to per cent of ash for groups of four the results are respectively, 4.0225, 4.5625, 4.6850, 4.9775 with two varieties closing the list at 5,95050. The results are in line with those notes for Tables I and II.

For the summer growth period there is a greater depression of the freezing point as compared with the blossoming period. There are, with the exception of Walbridge, Red Astrachan and Jonathan, higher values than for the dormant period. The moisture content has decreased from the figures of the preceding analysis, but is higher than at any period except blossoming period. Concerning the hardiness factor, the differences are only slight and do not conform to the systematic arrangement demanded in our proposed progression. The ash data for respective groups of four are: 4.7350, 4.2900, 4.3725, 4.4000 and for the last two 4.9700. They are consistent with those for Tables I, II and III except in the first group. It should be noted again, however, that the varieties are not absolutely identical in the different tables.

TABLE V

Wood-Ripening Period.

Date	Variety	Freezing point lowering (Δ)	Per cent moisture	Per cent ash (dry)	Hardiness factor
1920					
9-29	Hibernal	2.39	49.81	4.90	38.37
9-13	Oldenburg	2.21	53.67	5.60	42.79
9-13	Wealthy	2.44	52.98	5.07	43.88
9-20	Malinda	2.10	51.24	4.52	38.05
9-13	Yellow Transparent	2.54	55.04	5.61	48.24
9-29	Fameuse	2.46	51.66	4.73	41.83
9-20	Walbridge	2.09	51.45	4.57	38.34
9-29	McIntosh	2.16	51.88	4.39	39.58
9-29	Northwestern Greening	2.17	52.13	4.40	40.00
9-13	Salome	2.24	53.96	4.50	43.58
9-13	Red Astrachan	2.24	55.31	5.53	45.77
9-20	Roman Stem	2.20	53.08	4.59	41.79
9-29	Willow Twig	2.63	52.76	5.23	45.10
9-20	Jonathan	2.21	51.63	4.48	39.60
9-13	Mann	2.25	53.96	4.93	43.68
9-20	Winesap	2.28	51.53	4.25	40.09
9-29	Grimes	2.08	54.16	6.40	42.30
9-20	Ben Davis	1.91	51.09	5.85	36.07

In the period represented in Table V, there is generally a greater lowering of the freezing point (Ben Davis being an exception), a lower moisture content, a higher percentage of ash and lower values for the hardiness factor. It is interesting to note that

there is practically as much ash present at this time as was found in the sap during the blossoming period.

From the data submitted in Tables I to V, there is considerable variation in the freezing point depression, the percentage moisture and the ash. During the period at which buds are swelling, the lowering of the freezing point is least. On account of the high ash content during the period, it is logical to conclude that at that time the solutes of the cell sap are largely inorganic constituents. For the wood ripening period, the depression is even greater than for the dormant period. This is to be expected even though chemical tests were not made, for at that time much sugar will be stored in the stem tissues.

The averages for ash content for the varieties in groups of four are respectively, 5,0225, 4.8250, 4.7525, 4.7225, and for the last two 6.1250. In this case with the exception of the last, the results show a reverse gradation from that noted in Tables I, II and III.

Comparing the results obtained at different times during the year, especially those for the hardiness factor, the blossoming period gives us differences that at least will suggest variations, conforming to placings on a scale of hardiness made by many horticulturists in this section of the country. The ash content at this period where Hibernal has 3.01 per cent, Northwestern Greening 4.72 per cent and Grimes 5.48 per cent suggests itself as a possibility of being of some value in experiments in determining relative hardiness. As far as using the hardiness factor throughout and having a progressive gradation for each of the varieties, it is of course to be expected that there would be differences. But considering that the trees selected, although uniform for each variety, were in fact grown under varying conditions, the results at least warrant submission.

In order to substantiate the conclusions arrived at from the study of the fifteen year old trees, sap studies were made upon fourteen different varieties, many of them the same as tested previously, from the Mount Arbor Nurseries at Shenandoah, Iowa. The material was all two year old, grown under the same conditions and upon the same kind of stock. The data immediately following serve to bring out more forcibly various propositions derived from the work upon the orchard trees at Ames.

Noting the range which exists, 1.12 to 1.54, the moisture content 57.78 per cent to 65.59 per cent, the ash content 4.78 per cent to 6.13 per cent, the hardiness factor 38.33 to 45.62, it is immediately evident that there are present physical and chemical factors which are more easily comparable to those found for the blossoming period (Table III). It is apparent that any one of these factors is not in itself sufficient to be used as a scale for hardiness. However, it is noticeable that wherever the depression is small the moisture content is high. Whenever one variety has a relatively large freezing point lowering as compared to another variety of the same hardiness, the second variety has a correspondingly high percentage of moisture as compared to the first. Grimes and White Pearmain are regarded as being approximately of the same hardi-

TABLE VI

Physico-Chemical Data for Cell Sap of 14 Different Varieties of Two-Year-Old Nursery Trees Grown at the Mount Arbor Nurseries. Collections Were Made on August 12, 1920.

Variety	Freezing point lowering (△)	Per cent moisture	Per cent ash (dry)	Hardiness factor
Hibernal	1.23	58.74	4.78	38.33
Virginia Crab	1.27	58.58	6.37	38.78
Peerless	1.37	57.78	5.38	39.08
Saolme	1.17	61.22	5.79	40.49
Wealthy	1.35	59.42	5.83	40.96
McIntosh	1.30	60.41	5.12	41.61
Jonathan	1.31	60.88	5.96	42.42
Winesap	1.47	59.62	5.37	42.99
Northwestern Greening .	1.37	60.98	5.57	43.53
Delicious	1.31	62.55	5.27	44.77
Stayman Winesap	1.54	60.22	5.34	44.97
Grimes	1.40	61.97	5.59	45.33
White Pearmain	1.12	65.59	6.13	45.62
Ben Davis	1.44	62.00	5.81	46.15

ness, but Grimes has a greater depression by 0.28 or 25 per cent. The increase of the percentage moisture of the White Pearmain over Grimes is comparatively large, being 3.62 or an increase of 5.84 per cent. The product of △ times the moisture percentage in the case of Grimes is 86.76 while in the case of White Pearmain it is 73.46. These values are obtained because the per cent increase of moisture is about four times as large as the percentage increased for △. While the square roots of the freezing point lowering of Grimes and White Pearmain are respectively 1.183 and 1.058, the former variety has 11.8 per cent greater depression in its freezing point. Using the same varieties for moisture, the square of the percentages of each respectively when divided by 100 is equal to 38.40 and 43.02, an amount in favor of White Pearmain over Grimes of 12 per cent. The product of the square root of △ times the square of the per cent moisture divided by 100, gives what we designate as the hardiness factor.

We realize of course that by taking the square root of the depression of the freezing point lowering, the error present becomes minimized; on the other hand the square of the moisture content in percentage intensifies the error which would be present due to methods employed. However, the results presented are merely suggestions for placing the question of hardiness upon a more definite basis.

In Table VI, the varieties are listed according to range of hardiness as determined by the use of the new factor. There will naturally be some difference of opinion regarding certain varieties, but considering this, there is ample room for an elimination of at least one-third. If a proposed variety has a factor of 43.00, it will be placed in the Delicious-Grimes class and cannot successfully

compete with the Wealthy for the reason that it is not able to withstand the climate.

It is of course recognized that the data given in this publication are somewhat limited, yet the results obtained point out the responsibility of using the depression of the freezing point and the moisture content as an index in ascertaining comparative hardiness. The solutes which are responsible for differences in the ash appear to be significant in the general question of hardiness.

In summarizing this preliminary report of the comparative hardiness of different varieties of apples by this new hardiness factor, it is found: (1) That the time of the season is the important consideration in determinations of hardiness. Measurements and tests should be made at a time when all the metabolic processes of the plant possess their greatest activity. This occurs during the blossoming period and not during the dormancy period. (2) That two year old nursery stock offers suitable material for investigations of the ability to withstand the climatic environment. As trees of this kind have a more prolonged period of growth, it is possible to make a larger number of tests.

With pleasure, the authors wish to acknowledge the criticism and advice given by Professor S. A. Beach from time to time during the course of experimentation.

Items of Business

Constitution Suspended

It was moved that Article 6 of the Constitution be suspended and Section 6 of the By-Laws be amended to increase the dues to $2.50 per annum.

This motion met with a hearty response and was carried unanimously.

Amendment to the Constitution

It was moved and carried that a committee be appointed by the chair to report at this meeting on amending Article 3 of the Constitution which contains the qualifications for membership.

The article as amended reads, "Any person who has a baccalaureate degree and holds an official position in an agricultural college, experiment station, or federal or state department of agriculture in the United States or Canada, is eligible to membership. Other applicants may be admitted by vote of the executive committee."

The members of this committee were Messrs. Gourley, Beach, Dorsey, Crow, Chandler, Close, and Alderman.

Sectional Meetings and Quarterly Journal

It was voted that a committee be appointed to report at this meeting on the organization and policy of sectional meetings and also on the question of publishing a quarterly journal.

The report of the committee as adopted follows:

1. The sectional or regional organizations shall not be considered as auxiliaries to the American Society for Horticultural Science, but sections of it.

2. The Society wishes to encourage the formation of sectional conferences as a part of the activities of the Society, and provides, that for sections where no organization has been perfected, the President shall appoint a temporary leader through whom interested members may perfect an organization suitable to their conditions. Such organizations are requested to send a report of their proceedings to the Secretary for possible publication. The executive committee shall confer with the Secretary as to the advisability of publishing full or part reports of the sections.

3. Membership in the American Society for Horticultural Science shall constitute membership in the sectional organizations.

4. As to the publication of a quarterly journal in addition to the annual report, the committee further recommends that the matter be left with a special committee to be appointed by the incoming president, to report next year. The understanding being that this committee shall canvass the field carefully as to material available, publication cost, etc.

The members of this committee were Messrs. Dorsey, Barnett, Roberts, Crow, Chandler and Close.

Vote of Thanks to the Program Committee

It was voted that the sincere thanks of this Society be extended to the program committee, particularly Dr. J. K. Shaw, Chairman, for working up such excellent programs during the past two years.

Election of Officers

The officers and committees mentioned on page 4 were elected for 1921.

Report of Committee on Resolutions

Resolved that the thanks of this Society be extended to the committee on local arrangements and to the authorities of the Chicago University for providing facilities for holding our meetings, and for other courtesies.

S. A. Beach, *Chairman*,
J. H. Gourley,
J. K. Shaw.

Report of National Research Council Committee

The report of the National Research Council Committee was adopted and the Society voted to continue the committee with the understanding that when necessary the committees may make changes in the details of its work.

Committee of Sectional Chairmen

President Chandler appointed the following chairmen to take charge of forming sectional groups in their respective sections: J. W. Crow, J. K. Shaw, J. H. Gourley, T. H. McHatton, L. Greene, V. R. Gardner, E. J. Kyle.

The Northern Great Plains Section and the Pacific Coast Sections have been in operation for a couple of years.

Committee on Quarterly Journal

There are three members on this committee: H. D. Hooker, Chairman; L. Greene, and A. J Heinicke.

Committee on Research and Experimentation Discontinued

It was voted to discontinue the committee on research and experimentation.

Endorsing the New Policy of the American Pomological Society

At the smoker the outlook for an enlarged field for the American Pomological Society was discussed and the following motion was aodpted: "Moved that we endorse and will support the effort now being made to broaden the scope and enlarge the function of the American Pomological Society, and heartily approve also the establishment of collegiate memberships."

Dinner and Social Evening

Sixty-five members enjoyed the dinner and the social evening which followed. The honors of presiding were shared jointly by Professors J. C. Blair and S. A. Beach. Other speakers were B. S. Pickett, William Stuart, C. S Crandall and Frederic Cranefield, the latter being a guest The remarks were largely reminiscent dealing with the great work of Goff and Budd. The speakers from Illinois told about the building up and use of the great horticultural equipment at their University. Mr. Cranefield asked for endorsement and support of the new policy of the American Pomological Society, this was given.

Obituary

L. D. Jesseman

During 1920, the Society lost one member by death, Prof. L. D. Jesseman, horticultural specialist of the Hampden County Farm Bureau with headquarters at Springfield, Massachusetts. Previous to going to Springfield, Prof. Jesseman was connected with the Pennsylvania State College. The Secretary regrets that he was not able to obtain a sketch of Prof. Jesseman's life and activities, nor a photograph of him, to include in this report.

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W. H. CHANDLER

PROCEEDINGS

OF THE

AMERICAN SOCIETY

FOR

HORTICULTURAL SCIENCE

1921

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E. J. Kyle
J. C. Whitten

CONSTITUTION *

ARTICLE I

The name of this Association shall be the American Society for Horticultural Science.

ARTICLE II

The object of the Society shall be to promote the Science of Horticulture.

ARTICLE III

Any person who has a baccalaureate degree and holds an official position in an agricultural college, experiment station, or Federal or state department of agriculture in the United States or Canada, is eligible to membership. Other applicants may be admitted by vote of the executive committee.

ARTICLE IV

Meetings shall be held annually at such time and place as may be designated by the Executive Committee, unless otherwise ordered by the Society.

ARTICLE V

The officers shall consist of a President, three Vice-Presidents, and a Secretary-Treasurer, who, together with the chairman of the standing committees, shall constitute a Council to act upon all applications for membership. There shall be an Assistant Secretary. These officers shall be elected annually by ballot.

ARTICLE VI

This Constitution may be amended by a two-thirds vote of the Society at any regular meeting, notice of such amendment having been read at the last regular meeting.

BY-LAWS

SECTION 1. The President and other officers shall perform the usual duties of their respective offices. The President shall also deliver an address at each regular meeting.

SEC. 2 There shall be a Committee on Nominations consisting of five (5) members, who shall be nominated and elected by ballot at each regular meeting of the Society. It shall be the duty of this committee, at the following meeting, to suggest to the Society names for officers, referees, and members of committees for the ensuing year.†

SEC. 3. There shall be an Executive Committee, consisting of three (3) members and the President and the Secretary, ex-officio. This committee shall perform the usual duties devolving upon such committee.

SEC. 4. The Committee on Nominations shall nominate referees and alternates upon special subjects of investigations or instruction, which may be referred to its consideration by the Society. The duties of these referees shall be to make concise reports upon recent investigations or methods of teaching in the subjects assigned them, and to report the present status of the same.

SEC. 5. There shall be a Committee on Program, consisting of seven (7) members, of which the Secretary shall be one. This committee shall have charge of the scientific activities of the Society, except as otherwise ordered by the Society.

SEC. 6. The annual dues of the Society shall be two dollars and fifty cents.

SEC. 7. Ten members of the Society shall constitute a quorum.

*The Constitution and By-Laws as amended from time to time.
†Since 1913 two lists of candidates have been required.

MEMBERSHIP ROLL FOR 1921

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ALDERMAN, W. H. .....University Farm, St. Paul. Minn.
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MACKINTOSH, R. S. .....University Farm, St. Paul. Minn.
MACOUN, W. T. ....Central Experimental Farm, Ottawa, Canada.
MAGNESS, J. R. ....Marble Laboratories, Inc., Canton, Pa.
MALLOCH, W. S. ....University of Illinois, Champaign, Ill.
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MANN, A. J. ....Experiment Station, Summerland, B. C.
MARKELL, E. L. ....1101 Home Insurance Building, Chicago, Ill.
MARSHALL, R. E. ......Agricultural College, East Lansing, Mich.
MASON, A. F. ....Rutgers College, New Brunswick, N. J.
MATHEWS, C. W. ......Agricultural College, Lexington, Ky.
MATTHEWS, C. D. ......State Dept. of Agricultural, Raleigh, N. C.
MERRILL, M. C. ....Agricultural College of Utah, Logan, Utah.
MILWARD, J. G..........University of Wisconsin, Madison, Wis.
MOORE, J. G. ....University of Wisconsin, Madison, Wis.
MORRIS, O. M. ....Experiment Station, Pullman, Wash.
MULFORD, F. L. ....U. S. Dept. Agr., Washington, D. C.
MURNEEK, A. E. ....Oregon Agricultural College, Corvallis, Ore.
MYERS, C E. ....Experiment Station, State College, Pa.

NEFF, E. F. ....Dept. Agr., Simcoe, Ontario, Canada.
NESS, H. ....A. & M. College, College Station, Texas.
NICHOLS, H. E. ....Iowa State College, Ames, Iowa.
NIGHTINGALE, G. F. ....University of Wisconsin, Madison, Wis.
NISSLEY, C. H. ....Rutgers College, New Brunswick, N. J.

OLNEY, A. J. ....Experiment Station, Lexington, Ky.
OSKAMP, JOSEPH ....Cornell University, Ithaca, N. Y.
OVERHOLSER, E. L. ......University of California, Berkeley, Calif.

PADDOCK, W. ....Ohio State University, Columbus, Ohio.
PALMER, E. F. ....Vineland, Ontario, Canada.
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PELTON, W. C. ....Pennsylvania State College, State College, Pa.
PHILLIPS, H. A. ....State Teachers College, Warrensburg, Mo.
PICKETT, B. S. ....University of Illinois, Champaign, Ill.
POTTER, G. F..........Agricultural College, Durham, N. H.
PRICE, H. L. ....Experiment Station, Blacksburg, Va.
PLAGGE, H. H. ....Iowa State College, Ames, Iowa.
PROEBSTING, E. L. ......431 N. Tioga Street, Ithaca, N. Y.

RADSPINNER, W. A. .....Agricultural College, Stillwater, Okla.
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REED, H. J. ....Experiment Station, Lafayette, Ind.
REES, R. W. ....521 Cutler Building, Rochester, N. Y.

Reeves, F. S. ....Newton Cross, Prince Edward Island, Canada.
Rehder, Alfred ....Arnold Arboretum, Jamaica Plain, Mass.
Reimer, F. C...........Southern Oregon Experiment Station, Talent, Ore.
Richardson, F. B. .....A. & M. College, Agricultural College, Miss.
Richey, H. W. ....Iowa State College, Ames, Iowa.
Roberts, R. H. ....University of Wisconsin, Madison, Wis.
Robertson, W. F. .....Agricultural College, Amherst, Mass.
Rolfs, F. M. ....A. & M. College, Stillwater, Okla.
Rosa, Jr., J. T. ....University of Missouri, Columbia, Mo.
Ruth, W. A. ....University of Illinois, Champaign, Ill.

Sandsten, E. P. ....Agricultural College, Fort Collins, Colo.
Schuster, C. E. ....Agricultural College, Corvallis, Ore.
Scott, L. B. ....U. S. Dept. of Agr., Washington, D. C.
Sears, F. C. ....Agricultural College, Amherst, Mass.
Seaver, H. B. ....University of New Jersey, New Brunswick, N. J.
Shaw, J. K. ....Agricultural College, Amherst, Mass.
Shaw, P. J. ....Agricultural College, Truro, N. S.
Shoemaker, D. N. .....U. S. Dept. Agr., Washington. D. C.
Smart, W. A. ....Agricultural College, Corvallis, Ore.
Smith, A. G. ....Experiment Station, Blacksburg, Va.
Smith, L. B. ....Entomological Laboratory, Reverton, N. J.
Snyder, Elmer.........Hotel Willard, Fresno, Calif.
Sprague, T. O. ....Experiment Station, Geneva, N. Y.
Stahl, J. L. ....Western Washington Expt. Sta., Puyallup, Wash.
Starcher, G. C. ....Experiment Station, Auburn, Ala.
Stewart, John P. .... 305 Carlisle Ave., York, Pa.
Stuart, William ......U. S. Dept. Agr., Washington. D C.
Sweetser, H. P. ....University of Maine, Orono, Maine.

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Tapley, W. T. ....University Farm, St. Paul, Minn.
Taylor, R. H. ....2712 Dana St., Berkeley, Calif.
Taylor, W. A. ....U. S. Dept. Agr., Washington, D. C.
Thayer, Paul ....Experiment Station, Wooster, Ohio.
Thompson, H. C. ......Cornell University, Ithaca, N. Y.
Tompkins, C. M. ......Agricultural College, Fort Collins, Colo.
Tompson, H. F. ....Arlington 74, Mass.
Tracy, Sr., W. W.......U. S. Dept. Agr., Washington, D. C.
Tufts, W. P. ....University Farm School, Davis, Calif.
Tukey, H. B. ....Experiment Station, Geneva, N. Y.
Turney, A. C. ....Dept. of Agr., Frederickton, New Brunswick.

Vanderwort, H. S. ....West Virginia University, Morgantown, W. Va.
Van Meter, R. A. .....Agricultural College, Amherst, Mass.
Vierhaller, A. F. .....University of Maryland, College Park, Md.
Vinson, C. G. ....Pennsylvania State College, State College, Pa.
Vogele, A. C. ....Colfax, Ill.

Waid, C. W. ....Ohio Farm Bureau Federation, Columbus, Ohio.
Waring, J. H. ....Pennsylvania State College, State College, Pa.
Watts, G. S. ....Box 114, New Salem, Pa.
Watts, R. L. ....Experiment Station, State College, Pa.
Webber, H. J. ....University of California, Berkeley, California.
Wellington, J. W. ....U. S. Dept. Agr., Washington, D. C.
Wellington, R. ....Experiment Station, Geneva, N. Y.
Wentworth, S. W. ....Agricultural College, Durham, N. H.
Werner, H. O..........University of Nebraska, Lincoln, Neb.
Westcourt, F. W. .....John Tarleton Agr. College, Stephensville, Texas.
Westover, K. C. ....West Virginia University, Morgantown, W. Va.
White, E. A. ....Cornell University, Ithaca, N. Y.
Whitten, J. C. ....University of California, Berkeley, Calif.
Wiegand, E. H. ....Agricultural College, Corvallis, Ore.
Wiggins, C. C. ....University of Nebraska, Lincoln, Neb.
Wight, W. F. ....Chico, Calif.
Wilcox, L. P. ....Agricultural College, Corvallis, Ore.
Williams, L. C. ....Agricultural College, Manhattan, Kans.
Winberg, O. F. E. .....State Board of Horticulture, Silverhill, Ala.
Wood, M. N. ....409 Native Sons Hall, Sacramento, Calif.
Woodbury, C. G. ....National Canners Association, Washington, D. C.
Work, Paul ....Cornell University, Ithaca, N. Y.

Yeager, A. F. ....Agricultural College, Fargo, N. D.
Yerkes, G. E. ....U. S. Dept. Agr., Washington, D. C.
Young, W. J. ....Experiment Station, Wooster, Ohio.

Zimmerley, H. H. ......Virginia Truck Experiment Station, Norfolk, Va.

TREASURER'S REPORT FOR 1921

VOUCHER NO.	1921	CR.		
	Jan. 4	Stamps		$1.00
(1)	Jan. 5	Expenses of Secretary in attending 1920 meeting in Chicago		100.07
(2)	Jan 5	Torsch and Franz Badge Co., Baltimore, Md., 100 buttons for 1920 meeting		5.10
	Jan. 7	Stamps		4.00
	Jan. 10	Stamps		2.00
	Jan. 26	Stamps		1.00
(3)	Jan. 31	Expressage on Manuscript of 1920 report to printer		.41
	Feb. 8	Stamps		1.00
	Feb. 10	Postage and Insurance on letterheads and envelopes to officers		1.41
(4)	Feb. 11	The University Press, College Park, Md.		
		2,000 letterheads	$11.60	
		2,000 envelopes	9.50	21.10
	Feb. 15	Stamps		1.00
	Feb. 18	Stamps		1.00
	Mch. 16	Stamps		2.00
	Apr. 8	Stamps		1.00
	Apr. 22	Stamps		1.00
	May 10	Stamps		1.00
(5)	May 12	Freight on reports from printer in Harrisburg, Pa.		1.53
	May 13	Stamps on circular letters		4.30
	May 14	Stamps on reports		4.20
	May 24	Stamps		1.00
	May 25	Stamps		1.00
	June 4	Stamps		1.00
	June 9	Stamps		1.00
	July 5	Stamps		1.00
(6)	July 26	The Telegraph Printing Co., Harrisburg, Pa.		
		400 copies annual report 250 pages and cover	$550.00	
		400 copies 57 pages @ $2.30 per page	131.10	
		1 half tone and plate insert	6.40	
		Postage and mailing reports by printer	37.71	
		30 copies constitution and by-laws 30 copies membership roll and 20 copies combined index	11.25	
		Postage	.28	736.74
	July 26	Stamps		1.00
	July 30	Stamps		1.00
(7)	Aug. 8	R. E. Marshall, East Lansing, Mich.,		
		Jan. 10, 1921, Stamps	1.00	
		Mch. 14, 1921, Stamps	5.00	
		June 24, 1921, Stamps	5.00	
		July 15, 1921, Stamps and Envelopes	4.72	14.72
	Aug. 30	Stamps		1.00
	Oct. 4	Stamps		1.00
	Oct. 17	Stamps		6.00
	Nov. 12	Stamps		1.00
(8)	Dec. 3	R. E. Marshall, East Lansing, Mich. 275 2c stamped envelopes		6.16
	Dec. 3	Stamps		1.00
	Dec. 9	Stamps		1.00

Dec. 12	Telephone to the Telegraph Printing Co., Harrisburg, Pa.	.90
Dec. 15	Stamps	2.00
	To Balance	243.08
		$1,175.72
1920		
Dec. 29	By balance on hand	$140.22
Dec. 29	Iowa State College, Ames, Iowa, Report 1918	1.50
Dec. 29	N. L. Partridge, East Lansing, Mich., Report 1918	1.50
1921		
Jan. 6	G. E Stechert & Co., New York City, 2 reports for 1919	3.00
Jan. 10	A. C. McClurg & Co., Chicago, Ill., report 1919	1.50
Jan. 19	E. G. Kelly, Manhattan, Kans., report 1919	1.50
Jan. 26	New Mexico College of Agr. and Mech. Arts, State College, N. M. report 1919	1.50
Feb. 7	H. O. Werner, Lincoln, Nebr., report 1918	1.50
Feb. 9	Missouri State Fruit Experiment Station, Mountain Grove, Mo., report 1919	1.50
Feb. 11	J. E. Cannaday, Charleston, W. Va., report 1919	1.50
Feb. 12	Hon. T. K. Doherty, Ottawa, Canada, report 1919	1.50
Feb. 14	Pa. State College, State College, Pa., reports 1910, 1912, 1913, 1914, 1915, 1916, 1917 and 1919	9.50
Feb. 19	The Baker & Taylor Co., New York City, Report 1919	1.50
Mch. 1	H. O. Werner, Lincoln, Nebr., report 1919	1.50
Mch. 5	Mass. Agr. College, Amherst, Mass., report 1916	1.50
Apr. 9	The Franklin Square Agency, New York City, report 1913	1.00
Apr. 9	New Mexico College of Agr. and Mech. Arts, State College, N. M., Reports 1906, 1907, 1908 & 9, 1910, 1912, 1913, 1914, 1915, 1916, 1917, 1918 and 1919	14.00
Apr. 20	Prof. A. M. Sprenger, Wageningen, Holland, report 1919	1.50
May 9	Macdonald College, Macdonald P. O., Quebec reports 1912, 1914, 1915, 1916, 1917, 1918, and 1919	9.00
May 10	Macdonald College, Macdonald College P. O., Quebec, report 1920	2.50
May 13	R. Veterinary and Agr. College, Copenhagen, Denmark, report 1920	2.50
May 24	G. E. Stechert & Co., New York City, 3 copies of report 1920	7.50
May 25	Arnold Arboretum, Jamaica Plain, Mass., report 1920	2.50
May 25	Agricultural Exp. Sta., Blacksburg, Va., report 1920	2.50
May 31	Purdue University, LaFayette, Ind., report 1920	2.50
May 31	University of Minnesota, St Paul., Minn., report 1920	2.50
June 3	University of Vermont, Burlington, Vt., report 1920	2.50
June 4	Weldon & Wesley, Ltd., London, Eng., reports 1906, 1907, 1908 & 9, 1910, 1912, 1913, 1914, 1915, 1916, 1917, 1918, 1919	15.00
June 8	State College of Agriculture, Athens, Ga., Report 1920	2.50
June 8	Prof. Niels Esbjerg, Odense, Denmark, reports 1905, 1906, 1907, 1908 & 9, 1910, 1912, 1913, 1914, 1915, 1916, 1917, 1918, 1919, 1920	17.50
July 1	Colorado Agr. College, Fort Collins, Colo., Report 1920	2.50
July 1	State Department of Agriculture, Harrisburg, Pa., report 1920	2.50
July 1	Harvard University, Cambridge, Mass., Report 1917	1.50
July 1	Oregon Agr. College, Corvallis, Ore., Report 1920	2.50
July 1	State College of Washington, Pullman, Wash., Report 1920	2.50
July 1	Iowa State College, Ames, Iowa, Report 1920	2.50
July 1	Ohio State University, Columbus, Ohio, Reports 1920.	2.50
July 1	Brooklyn Institute of Arts and Sciences, Brooklyn, N. Y., Report 1920	2.50
July 1	Seattle Public Library, Seattle, Wash., Report 1920	2.50

July 1	University of Wisconsin, Madison, Wis., Report 1920.	2.50
July 1	Louisiana State University, Baten Rouge, La., Report 1920	2.50
July 1	Experiment Station, Experiment, Ga., Report 1920 ..	2.50
July 6	University of California, Berkeley, Cal., 3 Report 1920	7.50
July 11	United States Experiment Station, Honolulu, Hawaii, Report 1920	2.50
July 19	Experiment Station, Lexington, Ky., Report 1920	2.50
July 21	Southern Oregon Experiment Station, Talent, Oregon, Report 1920	2.50
July 22	G. E. Stechert & Co., New York City, Report 1920	2.50
July 22	Kansas Agricultural College, Manhattan, Kans., Report 1920	2.50
Aug. 8	Cornell Cooperative Society. Ithaca, N. Y., Reports 1915, 1916, 1917, 1918, 1919, 1920	9.50
Aug. 8	Agricultural College, Amherst, Mass., Report 1920 ..	2.50
Aug. 8	University of Nebraska, Lincoln, Nebr., Reports 1919, 1920	4.00
Aug. 25	College of Agriculture, Mayaguez, Porto Rico. Report 1920	2.50
Sept. 22	University of Missouri, Columbia, Mo., Report 1920 ..	2.50
Sept. 27	Experiment Station, College Station, Texas, Report 1919	1.50
Sept. 27	Prof. Angelo Manaresi, Bologna, Italy, Report 1919..	1.50
Oct. 21	J. H. Waring, State College, Pennsylvania, Report 1920	1.50
Oct. 2	Cornell University, Ithaca, N. Y., Report 1920	2.50
Nov. 4	Utah Agricultural College, Logan, Utah, Report 1920 .	2.50
Nov. 4	A. C. Hildreth, Pullman, Wash., Report 1920	1.50
Nov. 12	New Mexico College of Agr. & Mech. Arts, State College, N. M., Report 1920	2.50
Nov. 15	Whelden & Wesley, Ltd., London, Eng., Reports 1919, 1920,	4.00
Nov. 22	Experiment Station, Wooster, Ohio, Reports 1916, 1918, 1919, 1920	7.00
Nov. 29	University of California, Berkeley, Cal., Report 1920 .	2.50
Dec. 9	Purley L. Keene, Brookings, S. D. Reports 1914 1915, 1916, 1917, 1918, 1919	9.50
Dec. 19	University of Maine, Orono, Maine. Report 1920	2.50
Dec. 24	Annual Dues collected since last meeting	810.50
		$1,775.72
	Balance on hand	$ 243.08

Respectfully submitted,
C. P. CLOSE, *Treasurer.*

The Auditing Committee reported that it had examined the accounts of the Treasurer and found them to be correct.

E. F. PALMER,
R. WELLINGTON,
R. D. ANTHONY,
Auditing Committee.

ANNUAL MEETING AT TORONTO, CANADA,

December 28, 29, and 30, 1921

The meeting was called to order by President Chandler who presided at all of the sessions. The opening session started off at a lively pace which was held throughout the entire meeting. The papers were excellent and, notwithstanding a full program, there was time for a lot of snappy discussion. Unfortunately, several members who were on the program were not present so some of the papers were read by title only.

About 60 members attended the meeting though not all at any one session. There were many visitors and at some of the sessions the audience numbered about 80. The joint session was attended by about 100 people.

Six of the charter members were present—Blair, Close, Fletcher, Hedrick, Macoun and Stuart.

Growth of Apple Seedlings

By C. S. Crandall, *University of Illinois, Champaign, Ill.*

GROWING seedlings to fruiting maturity is an essential and chief part of an apple breeding project. Flowers are emasculated and pollinated, fruits mature, seeds are saved and planted. The following spring seedlings appear. What of the development of these seedlings? To what extent do individuals within a group vary in vigor and habit? Is development uniform and degree of growth the same in each succeeding year? Is increase slow or rapid, uniform or variable? Information on these points is meager.

A century ago under the demand for better varities, apple seedlings were grown in quantity by nurserymen in the hope that varieties better than any then recognized might appear. In this work promising individuals were selected, all others destroyed, and no record kept. That was commercial practice and can not be followed in breeding practice where studies are to be made of performance of progeny from different combinations of parents.

Most seedlings grown under breeding projects are hybrids from controlled pollinations. It would be very desirable to grow seedlings in quantity from self-pollinated flowers of parent varieties, with a view to the study of variation among seedlings in the hope that some clue to ancestry might be obtained, but unfortunately this proceeding is extremely difficult because of the prevailing self-sterility among apple varities.

Information regarding the value, for breeding purposes, of recognized orchard varieties, or of the numerous native and introduced crab-like species and varities of the genus, is almost entirely wanting. It is assumed that as these apple forms exhibit wide differences in tangible characters they will also vary widely in breeding capabilities, but with present knowledge the bringing together of compatible parent plants is a matter of chance. For this reason is it justifiable, in breeding for a first generation, to multiply the number of combinations and grow as many seedlings as possible from each combination in order that by study of large numbers of progeny correct determination may be made of the combinations that promise best results in future work. This determination regarding a particular pair of varieties is not an easy matter for it should not rest upon the experience of a single season. It has occured a number of times that the attempted union of two chosen parent plants was a failure, or near-failure, in one or more seasons and then, in a subsequent season, resulted in a high degree of success. Certain varieties like Oldenburg and Rome Beauty have been used, in almost all instances, successfully. Other varieties like Arkansas, Winesap and Stayman Winesap fail with almost equal regularity. Delicious is a good pollen parent, but fails as a female parent.

The basis for determination of desirable parents should rest in large degree upon study of the progeny and this study should begin with germination of the seeds and be followed through the years to full maturity. Success obtained from a particular mating can not be measured from the numebr of fruits matured from a given number of pollinations, nor can it be determined from the seed content of fruits or germination of seeds. These things are steps in the procedure and are, of course, taken into consideration, but the final measure of success must rest upon the vigor and desirable qualities of the seedlings.

Beginning in 1910 the Illinois station has each year grown a varying quantity of apple seedlings from seeds from controlled pollinations. There have been used in the crosses 44 orchard varieties and 47 crabs or crab-like forms representing native and introduced species and varieties of the genus Malus.

Nearly 1400 different combinations of parents have been attempted. Seedlings appearing above ground numbered 32,691 representing 57.74 per cent of the 56,616 seeds planted. These seeds represented about 900 different combinations and the seedlings now living are from approximately 700 different parental combinations.

Naturally with so many groups derived from so many unlike parent forms, with many of the combinations representing what may truly be called violent crosses, great differences in behavior were to be expected. There have been no precedents to guide in choosing forms to be combined and many pairs have been mated for the express purpose of ascertaining the breeding possibilities of the forms thus brought together. There have been surprises and disappointments. Surprises in the success of such violent crosses as Rome Beauty X Malus floribunda, Tolman X

Malus Toringo, Malus Siberica (19,643) X Oldenburg, and disappointment in results obtained with our native Malus Soulardi and Malus Ioensis.

After obtaining seeds from fruits of crosses there have been complete failures in germination. Thus in 1916 flowers of Malus Sargenti were pollinated with pollen of Jonathan, Lady, Oldenburg, Grimes Golden and Yellow Transparent. The 108 pollinations were 64.81 per cent successful; 70 fruits were matured; 165 seeds were planted, not one germinated. Malus Toringo X Winesap from 13 pollinations gave 9 fruits with 27 seeds and the same species X Yellow Transparent yielded 20 fruits with 36 seeds from 95 pollinations; here were 63 seeds, not one of which germinated. On the other hand certain groups have a record of perfect germination. A form of Malus baccata (806) X Domine with 37 seeds; Malus baccata maxima X Osimoe with 18 seeds, and Winter Rambo X Grimes Golden with 20 seeds, germinated every seed planted. Two crosses in which Wythe was pollinated by Rome Beauty and Willow yielded 270 seeds, 95 per cent of which germinated. There are a number of other groups in which germination ranged above 90 per cent, but for the aggregate of seeds planted germination is brought down to 57.74 per cent.

Record of germination is maintained and by this is meant appearance of cotyledons above ground. Doubtless some seeds may send out the radicle and even elongate the hypocotyl, but if they have not vitality sufficient to push the cotyledons above the surface they remain classed with failures to germinate. There is also maintained a performance record for each seedling for each year. For this record three measurements, height, spread and diameter are recorded at the end of each growing season, together with a general rating as to quality which gives each seedling place in one or the other of the three grades, "Good", "Fair", and "Poor".

The black soil of Central Illinois is not a nursery soil; it is not adopted to the growing of apple seedlings and first year results are often discouraging. In some groups the influences that retard growth in the first year appears to be inoperative in the second and succeeding years; in other groups it is not until the fourth or fifth year that normal vigorous growth is established.

There are a few groups of seedlings that have exhibited an excess of vigor from the beginning; a vigor that called forth comment even at time of germination. Such are seedlings of the 1911 cross Tolman X Malus Toringo, the 1912 cross Tolman X Malus atrosanguinea, and the 1914 cross Rome Beauty X Malus floribunda.

Seedlings of certain other groups were so uniformly deficient in vigor that none lived through the first year; as an example I may cite the 1915 cross Malus Ioensis X Collins with 31 germinations; most of the seedlings died within a month of germination and none survived the season. In still other groups, exhibiting debility from the beginning, most seedlings die within

a few weeks of germination, but a small minority may linger on for four or more years and, rarely, may attain fruiting maturity.

Here the experience with Malus Soulardi may be referred to. This species is a native; it is hardy, vigorous, has abundant dark green foliage, and is productive. It is desired to hybridize it in the hope that progeny, while retaining the vigor and tree characters of Soulardi will exhibit less acerbity and increased size of fruit. To this end Malus Soulardi has been used as the female parent in 26 crosses with 13 orchard varieties and three crab forms. The three attempted crab crosses failed entirely, as did 7 of the crosses by orchard varieties. Fruits of two crosses were seedless and seeds from one cross failed in germination. Thirteen crosses by five varieties gave 121 seeds, 67 or 55.37 per cent of which germinated.

The percentage of germination is fair, there is no cause for complaint on this score; but the seedlings, the final product upon which judgment of the crosses must rest, without exception bore unmistakable evidence of constitutional weakness. To-day 19 are living, one at five years of age and 18 at four years of age; 72 per cent of those represented at time of germination have died; the living all grade as "poor" and it is a safe prediction that not one will live to fruiting maturity. Pollen of Malus Soulardi has been used on flowers of three varieties, but wholly without success.

Results with Malus Ioensis are fully as discouraging as are those with Malus Soulardi. In the years 1915-1918 pollen of five varities was used on 408 flowers; fruit matured numbered 151 and these contained 857 seeds, 455 of which germinated. In October 1921, 34 seedlings were living, half of them 5 years old, the others 3 and 4 years old. There was a loss in the period from germination of 421 seedlings or 92½ per cent of the number at time of germination.

This high death rate was due entirely to constitutional debility; the seedlings were too weak to live. Of the 34 now living 17 are of the cross by Jonathan and 8 of the cross by Ben Davis; all these are graded as "poor". Of the six seedlings of the cross by Pewaukee, 4 are graded as "poor", and two doubtfully as "fair". The remaining three are of the cross by Wealthy; two of these are "poor" and one is "good". This one seedling stands out in marked contrast with others of the Ioensis groups and is the only one that appears likely to survive to maturity. Malus Ioensis has been used as a pollen parent because everything else is through blooming before pollen is mature enough for use.

In contrast with the poor results, due to constitutional debility of seedlings attained with the two species Soulardi and Ioensis, a few crosses giving good results may be cited; Longfield X Malus Niedwetzkayana with 49 germinations has 47 seedlings or nearly 96 per cent living at the close of the fifth year. Rome Beauty X Malus floribunda has 118 seedlings living at the end of the seventh year, out of 129 germinations; the loss in seven years is only 11 seedlings or 8½ per cent and the liv-

ing seedlings grade as 84 per cent "good", 15 per cent "fair", and one per cent "poor". Malus Toringo X Fanny has 49 seedlings, five years old, from 54 germinations. Wythe X Longfield has 41 of 44, Longfield X Shackleford 65 of 70. In these two groups the seedlings are six years old and the loss for the six year period is in each case approximately 7 per cent. In all these groups weak seedlings constituted a small minority; most seedlings were vigorous and exceptionally so in the cross Rome Beauty X Malus floribunda.

At the time this Rome Beauty X Malus floribunda cross was made, pollen of Malus floribunda was also used on flowers of Shackleford, Ben Davis, Winesap, Grimes Golden and Jonathan. Numbers of trees in the six crosses range from 27 for the Ben Davis cross, to 118 for the Roman Beauty cross; the average is 56. The majority of trees in all the crosses are vigorous, but no group equals Rome Beauty in apparent excess of vigor. However, at the October rating three groups, Shackleford, Winesap and Grimes Golden exceeded the Rome Beauty group in that they had raised all seedlings out of the "poor" class. The Jonathan group still has 16 per cent in this lowest class; the Ben Davis group 4 per cent, and, as already stated, the Rome Beauty group one per cent.

Considering the relative positions of the six groups with reference to average height for each of the seven years it appears that the Rome Beauty had the highest average in the first year and maintained that position hrough all years; in average spread it occupied fifth place in the first year, rose to third in the third year, dropped to fourth place in the sixth year, and held that position in the seventh year, being exceeded by the Winesap, Ben Davis and Shackleford groups. In average diameter it held first position from the first to the sixth year and was exceeded by Winesap in the seventh year.

The Grimes Golden group ended the seventh year in second place as to height, fifth as to spread, and fourth in diameter. The Jonathan group ends at the bottom in all three measurements and, in general, is the least desirable of the six groups. Malus floribunda has one characteristic that appears in the progeny from all crosses in a marked manner and that is a tendency of the production of long willowy shoots. Seedlings having Malus floribunda as either male or female parent are readily distinguished by this character, at least between ages of 4 to 10 years. In older trees the tendency is less marked.

To further illustrate performance of hybrid seedlings a series of six groups from pollinations of 1912, which now have record for nine years, is selected. These six groups of seedlings are from the mother plant, a tree of fairly vigorous growth and strictly erect habit which is carried in our lists as a variety of Malus prunifolia. The species Pyrus prunifolia was first recorded by Willdenow in his enumeration of Linnean species in 1797 and is said to have been introduced from Siberia in 1758; it is decribed as having persistent calyx lobes. That our form is not pure, but probably a hybrid, is indicated by the fact that nearly

three per cent of the fruits have the calyx lobes regularly deciduous.

On May 3, 1912, 183 flowers on six upright branches were emasculated; on May 7 these were pollinated as follows: 33 by Ben Davis, 24 by Tolman, 33 by Rome Beauty, 34 by Oldenburg, 34 by Domine, and 25 by Grimes Golden. The fruits picked and described numbered 165 representing 90.16 per cent of the pollinations. Ben Davis was 100 per cent successful; Tolman, Rome Beauty, and Oldenburg had percentages above 90, Domine had 82 per cent and Grimes Golden 76 per cent. Success of the pollinations indicates a high degree of compatibility between Malus prunifolia and the various varieties supplying pollen.

Seed production was good; group averages range from 5.77 seeds to each fruit for the Oldenburg cross to 8 seeds to each fruit for the Domine cross; for the six groups the average was 7 seeds to each fruit. Germination ranged from 62 to 76 per cent with an average for the six groups of 72 per cent.

Noticable differences in the groups, in numbers of weak seedlings, were observed at time of germination and it is found that in the period between appearing above ground and planting in nursery, losses ranged from 23 per cent for the Ben Davis group to 8 per cent for the Grimes Golden group. This initial loss did not eliminate all weak seedlings; many others died during the first two years, and the groups came to the end of the ninth year with losses for the full life period ranging from 42 per cent for the Rome Beauty group to 61 per cent for the Oldenburg group with an average loss for all groups of 51 per cent. Numbers of seedlings now living in the various groups are Ben Davis 107, Rome Beauty 82, Domine 68, Tolman 56, Oldenburg, 47; and Grimes Golden 40.

First year growth,—Growth the first year was small for seedlings of all groups. The minimum height of one inch was represented in all groups. Maxima ranged from 8 to 22 inches. Averages by groups were Rome Beauty 6.6 inches, Tolman 6.3 inches, Domine 6.2 inches, Ben Davis 5.44 inches, Oldenburg 4.78 inches, and Grimes Golden 3.55 inches. For the 400 seedlings in the six groups the average was 5.48 inches. Diameters were very small, the average for each of the three groups Rome, Tolman and Ben Davis was .11 inch; for the Domine and Oldenburg groups .10 inch and for the Grimes Golden group .09 inch.

Second year growth,—Height increment for the second year was greatly in excess of the increase for any other of the nine years for all groups. The Grimes Golden group had the lowest minimum height of 4 inches, also the highest maximum of 36 inches; average height for the group was 18 inches, a gain of over 400 per cent. The Oldenburg group stood next with a gain of 271 per cent, followed by the Tolman group with 247 per cent, the Ben Davis group with 241 per cent, Domine group with 222 per cent and the Rome Beauty group with 217 per cent. The Tolman group had the largest average height, 21.89 inches, with the Rome Beauty group second with an average height of 20.95 inches. Second year diameters were not recorder.

Third year growth,—The third year height increment was much less than for the second year. For all groups the increase over the second year was 64 per cent and the range by groups was from 52 to 79 per cent. Average diameters ranged from .38 inch for the Ben Davis group to .46 inch for the Rome Beauty group. For all groups the average was .42 inch, an increase for the two years of approximately 300 per cent. In this third year spread began to be appreciable although there were still 24 per cent of the seedlings remaining as branchless whips.

Fourth to eighth years,—For the succeeding five years 1916-1920, there was considerable uniformity in the rate of increase in height of the different groups and only the average percentage of increase by years for the six groups taken together need be mentioned. These percentages were, for 1916, 59; for 1917, 39; for 1918, 19; for 1919, 31; and for 1920, 13.

Diameter increase for the five year period was not so uniform in the several groups as was height increase, but the differences need no special comment further than to say that percentages of increase in diameter do not drop in 1920 as did percentages of increase in height. For all groups the increases in diameter were 83 per cent for 1916; 63 per cent for 1917; 33 per cent for 1918; 34 per cent for 1919 and 31 per cent for 1920.

Increase in spread was uniform except for the year 1918. In this year percentages of increase ranged from 3 per cent for the Tolman group to 23 per cent for the Grimes Golden group; a marked decrease from the record of 1917 in which the Tolman group increased 93 per cent and the Grimes Golden group 82 per cent. In the succeeding year—1919—these two groups are equal, each scoring an increase of 35 per cent. For the five years the percentages of increase for the combined groups, by years, were 1916, 156; 1917, 81; 1918, 11½; 1919, 35; and 1920, 18.

Ninth and last year,—The 400 trees of the six groups in which Malus prunifolia served as the mother parent ended the ninth year with a difference between the extremes of average height, as determined for each group, of only 7.19 inches; a difference between the extremes of average spread of 32.6 inches and between the extremes of average diameter of .69 inch.

Seedlings of the Rome Beauty cross take first place in height and diameter, but have third place in spread. The Ben Davis group is second in height and spread and third in diameter; the Tolman cross is third in height, first in spread and fifth in diameter; the Grimes Golden cross fourth in height, fifth in spread, and second in diameter; the Domine cross fifth in height, fourth in spread and diameter and the Oldenburg cross sixth in all three of the measurements.

Trunk diameter is a more reliable index of growth performance than is either height or spread because accidents, control of rampart branches, or other necessary pruning may affect a sufficient number or individuals to materially influence the averages in height or spread of any group of seedlings. The groups under

consideration range in diameters as follows: the Rome Beauty has the highest average, 3.87 inches, with a maximum of 5.2 inches and a minimum of 2 inches. The Grimes Golden group follows with an average of 3.82 inches, a maximum of 5.5 inches (the highest attained in any group) and a minimum of 1.2 inches. Next comes the Ben Davis group with an average of 3.75 inches, a maximum of 5.1 inches and of minimum of 1.3 inches; this is followed by the Domine group with an average of 3.55 inches, a maximum of 4.9 inches and a minimum of 1 inch; the Tolman group with an average of 3.54 inches, a maximum of 5.3 inches and a minimum of 2.3 inches, and the Oldenburg group with an average of 3.18 inches, a maximum of 4.6 inches and a minimum of 1 inch. Thus the extreme difference between minima is 1.3 inches, between maxima .9 inch and between averages .69 inch.

These differences are not excessive and it appears from study of the records and of the trees in orchard, that this particular form of Malus prunifolia may class as a good breeder, that it accepted pollen of six varieties with about equal favor and that the six groups of seedlings had a reasonably uniform development to the end of the ninth year.

Inheritance of Foliar Glands of the Peach *

By C. H. CONNORS, *Experiment Station, New Brunswick, N. J*

THE foliar glands of the peach have been recognized for about a century and their use in classification has been in vogue for about the same period. Gregory (5) has considered both the historical side and the taxonomic value of this type of appendage. A few conclusions regarding the feasibility of using glands in the classification will be considered later in this paper.

VARIATION IN GLANDS

Dorsey and Weiss (3) have shown in the case of the plum that the leaf glands are more or less constant with respect to number and position. This cannot be said of the peach, however. In the case of some 70 varieties and 1026 seedlings having reniform glands, the number, position and even the size are exceedingly variable. In one season, the foliar glands may vary from 2 to 8 in number and the next season, on the same variety, the variation may be from 2 to 4. This apparently is influenced by the conditions of growth. As to location, 1 to 4 may be found on the petiole and 1 to 6 on the margin of the leaf. In the latter case, the glands replace the normal spines, or

* Paper No. 66, of the Journal Series, New Jersey Agricultural Experiment Stations, Department of Horticulture.

glandules, which are present upon the crenations. It is a relatively rare case when a glandless leaf is found upon a variety which has reniform glands, and such cases usually occur very late in the growing season, especially if the latter part of the season has been dry. The globose glands also vary considerably in number. Frequently leaves may be found bearing no glands and the number may be as many as 8, but the usual variation is from 0 to 4. The position of this type of gland varies also, but not so many are to be found on the margins as in the case of the reniform type. In size, the reniform glands vary from large to small. The peaches of the so-called Chinese Cling group usually have large glands, but these vary from large to small in the same leaf. Some of the marginal glands almost lose their distinctive shape, becoming small and round in shape, but they may be easily distinguished from the small, marginal globose glands by both form and color, the globose glands being of a yellow cast. The reniform glands vary in size also by season. In some years the largest glands are noticably smaller than in others,

The glands on the Bolivian and Mexican peaches which have been introduced by the United States Department of Agriculture, are reniform, but they are small. These are not likely to be confused with globose glands. The globose glands do not vary so greatly in size as do the reniform glands.

There is present also, though Gregory appears to have overlooked it, a correlation between the type of the gland and the indentations on the margin of the leaf. The glandless leaves are distinctly serrate, usually compound. The margins of the leaves bearing globose glands are crenate, but verge on the serrate; and such leaves on a tree which normally have globose glands that fail to form glands become almost like normal glandless leaves. On the other hand, the margins of leaves bearing reniform glands are distinctly crenate and very rarely verge on the serrate. Usually, one can tell by looking at the margin of the leaf what type of gland the leaf carries.

The variety testing orchards of peaches at Vineland and New Brunswick, containing at various times about 100 varieties and many seedlings secured from breeding together a number of commercial varieties, offered a very good opportunity for studying various tree characters. Among these 100 varieties and about 2300 seedlings, the writer so far has been unable to find a single instance of a seedling, or variety, that possessed glands of the so-called mixed type, that is, with both reniform and globose glands upon the same leaf, or even upon the same tree. The very small reniform glands that appear on the margin, as has already been stated, on close examination fail to resemble globose glands. Among the globose glanded varieties confusion is apt to result from two causes. After the glandular structure has sloughed off, the remnant of the gland usually appears to be reniform. In some other cases, a side view of the globose glands gives an aspect like that of the reniform, especially if the gland is slightly distorted in growth. Hence, in classifying the seed-

lings as to type of gland, only the reniform and the globose are recognized.

Study of Seedlings—Reniform Selfed and Reniform x Reniform

In the cases where reniform glanded varieties were bred, all save two gave seedlings all of which bore reniform glands. These are as follows: Belle self-pollinated, 270; Carman self-pollinated, 20; Elberta self-pollinated, 138; Lola self-pollinated, 81; Slappey, self-pollinated, 12; total, 511 all with reniform glands. Belle X Elberta, 66; Belle X Greensboro, 208; Carman X Slappey, 4; Elberta X Greensboro, 111; Lolo X Arp, 52, Lolo X Slappey, 35; Slappey X Dewey, 39; total, 515, all reniform. In the cross of Slappey X Arp 23 came with reniform glands and 6 with globose glands. It is possible that an accidental mixture has taken place in this instance either at the time of harvesting the seeds from which the trees came or in planting the trees in the orchard, because the six with globose glands resemble closely the seedlings from Slappey X Earley Crawford. Elberta X Belle gave 79 seedlings with reniform glands and 20 with globose glands. Here also mixture is probable. It will be noted that of the total of 1026 seedlings (disregarding the Slappey X Arp and Elberta X Belle) not one was obtained which had glandless leaves, and with the exceptions noted, all had reniform glands.

Globose Self-Pollinated

Unfortunately, only one variety that has globose glands was self-pollinated. This was Early Crawford from which 84 seedlings were obtained, 27 of which had globose glands, 37 reniform glands and 20 were glandless, almost a 1:2:1 ratio. Some open-pollinated seedlings of St. John were grown, but no exact record was made of their behavior. Most of these appeared to be selfed and part of them had glandless leaves part had globose glands, but whether any had reniform glands is not now known.

Reniform X Globose

The seedlings secured from crossing varieties of these gland types are as follows: Belle X Early Crawford, 52 reniform, 79 globose; Elberta X Early Crawford, 58 reniform, 17 globose; Lola X Early Crawford, 25 reniform 36 globose; Slappey X Early Crawford, 3 reniform, 3 globose; total 138 reniform and 135 globose, almost a 1:1 ratio. The behavior of Elberta X Early Crawford varied somewhat from others in that the ratio is approximately 3:1. However, the population is small and such ratio might be expected from the way the seedling trees behave. For example, as many as six trees bearing fruits of rubbery texture were found in succession in one row, while not another one of the same type would be found until two or three rows distant.

Globose X Reniform

The results from crossing varieties with globose glands by varieties with reniform glands, are as follows: Early Crawford

X Arp, 7 reniform, 2 globose; Early Crawford X Belle, 15 reniform, 14 globose; Early Crawford X Dewey, 4 reniform, 1 globose; Early Crawford X Elberta, 13 reniform, 28 globose; Early Crawford X Greensboro, 22 reniform, 13 globose; Early Crawford X Slappey, 16 reniform, 14 globose; St. John X Early Wheeler, 22 reniform, 24 globose; St. John X Greensboro, 10 reniform, 13 globose; total, 109 reniform, 109 globose.

The Early Crawford X Elberta seedlings gave a ratio of about 1:2 in a rather small population, whereas in the reciprocal a ratio of approximately 3:1 was obtained. It would seem that the lack of balance in the ratio is accidental.

Discussion

In view of the evidence of these data, it is rather unfortunate that breeding was not done with varieties having glandless leaves. However, most of this type are worthless from a commercial standpoint, being more susceptible to attacks of peach leaf curl, Duggar (4), and of mildew—own observations and Rolphs (7). Campbell (2) states that varieties with glandless leaves are less susceptible to aphis injury. Campbell makes mention of Amygdalus persicoides, a wild form found in the Caucasus Mountains which Koch (6) states to be a natural hybrid between the peach and the almond (globose glands). This form has glandless leaves.

From the data here presented, it would appear that the reniform glands are a pure breeding type, whether they occur in the more homozygous varieties like Carman and Greensboro, or in varieties such as Elberta and Belle which may have arisen from crosses between races. The globose type of gland behaves like an intermediate type with the glandless type of leaf the recessive. Further studies are necessary to verify this. The matter harks back to the old question of the original habitat of the peach and the original form or forms of tree, flower and fruit.

Relation of Size of Blossom and Type of Gland

In Poiteau's classification (see Gregory), no correlation is established between size of blossom and type of gland, and large and medium sized blossoms occur on trees having glandless leaves, while no glandless leaved small blossomed type is shown. Campbell does find a correlation of large blossoms and reinform glands, small blossoms and globose glands, medium sized blossoms and either reniform or globose glands. These are based on reports upon collections of 90 varieties.

Of the varieties used in these breeding experiments upon which varieties and their progeny actual measurements of the petals have been made to determine the size of the blossom. Arp, Carman, Early Wheeler, Greensboro and Lola have large blossoms and reniform glands; Belle and Elberta have medium sized blossoms and reniform glands; Early Crawford and St. John have small blossoms and globose glands. Of the seedlings hav-

ing reniform glands, 450 had large blossoms, 184 small blossoms and 610 medium sized blossoms; of the seedlings having globose glands, 1 had large blossoms, 92 small blossoms and 170 medium sized blossoms; of the seedlings having glandless leaves, 20 had small blossoms.

There seems to be no definite correlation between size of blossom and the type of foliar glands.

Taxonomic Value of Foliar Glands

To a limited extent, foliar glands of the peach may be of assistance in classifying varieties. In the more southern peach districts, however, the varieties most widely planted have reniform glands; in the Michigan, New York and Ontario peach districts are still grown many varieties with globose glands. The glands, then might be of assistance in disclosing variety substitution.

Many varieties of peaches reproduce themselves fairly uniformily from seeds. Among these are Elberta, Heath Cling, Early Crawford and probably Iron Mountain and others. Seedlings from these varieties and possibly others have been not infrequently substituted for the parent and under the parental name. In this way, variations in tree characters are very likely to occur. As an example, there are two types of Iron Mountain in cultivation, one with large blossoms and one with small blossoms. The former is evidently a seed variety rather than a clonal variety.

By such a method there could be included within a variety types found in different localities that would have reniform glands, globose glands or even no glands, as might be illustrated by Gregory on page 218 under the head of "Indistinctive Glands". If the behavior of the progeny of Early Crawford with respect to foliar glands, is indicative of the behavior of all varieties with globose glands, in that seedlings were obtained with reniform glands, globose glands and no glands, we might expect, where each nurseryman had his own strain of certain varieties, perhaps raised from seed, to find conflicting reports as to the type of glands on individual strains of these varieties. For example, the variety Early Crawford originated in New Jersey. It would be very possible for a nurseryman in New York or Ontario to have a strain of Early Crawford with reniform glands or with no glands. The same might be true of St. John. Such might also be the case with varieties in Gregory's list of indeterminate glands, such as Early Newington, Orange Cling, Oldmixon Cling and others.

Summary

Three types of leaves of the peach are recognized, those having reniform glands, those having globose glands and those having no glands.

The reniform glands are kidney-shaped and sessile, varying in number, size and position. The number varies from 2 to 8 or more, and rarely is a glandless normal leaf found on a variety

that has reniform glands. They may be located on the petiole or on the margin of the leaf replacing spines. The marginal glands are smaller than the petiolar glands and may be distinguished from the marginal globose glands by shape and by the pale green color as compared with the yellow color of the globose gland.

The globose glands are round in cross sections, variable in number, size and position. The numbers vary from 0 to 8, usually 0 to 4, in size they are smaller than the reniform. They may be located on the petiole or margin, in the former case stalked and in the latter case sessile. Glandless leaves are frequently found. Leaves having reniform glands have crenate margins and the occassional glandless leaf is crenate. Leaves having globose glands have a serrate-crenate margin and the glandless leaves are serrate. Leaves typically with no glands are doubly and sharply serrate.

Of over 100 varieties and about 2300 seedlings examined. none had both reniform and globose glands on the same leaf, or on the same tree.

Early Crawford, globose glands, self-pollinated, yielded 27 seedlings with reniform glands, 37 with globose glands and 20 with no glands, a ratio of nearly 1:2:1.

Reniform glanded varieties: Arp, Belle, Carman, Dewey, Elberta, Greensboro, Lola, Slappey: when selfed, or crossed, gave 1026 seedlings, all with reniform glands, Slappey X Arp gave 23 reniform, 6 globose; and Elberta X Belle, 79 reniform and 20 globose. In the latter two cases, the fruit descriptions show a possibility that an accidental mixture of seeds or trees may have taken place.

Reniform X globose and globose X reniform, using Arp, Belle, Dewey, Early Crawford, Early Wheeler, Elberta, Greensboro, St. John and Slappey gave 247 reniform and 244 globose.

These figures (with the exceptions noted in the reniform X reniform group) give approximate ratios of what might be expected in crossings if the two contrasting types are reniform and glandless, the former dominant, with the globose an intermediate.

Glandless leaved seedlings came only in the globose type self-pollinated, none appearing where reniform glands were on one or both parents.

No correlation was found between size of blossom and type of glands.

Glands are of little actual value for classification for the differentiation of varieties, but may be practical aids for detecting substitution of varieties.

The indeterminate type of gland in which a variety may have globose or reniform glands in different localities, may be due to new strains arising from the old type variety as seedlings, especially if the old type had globose glands, or if there were accidental crossings of different gland types.

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Recent Progress in the Development of Improved Strains of Greenhouse Tomatoes, Lettuce and Cauliflower

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THE development and maintenance of suitable varities and strains of greenhouse vegetable crops is a problem of considerable importance and one that has caused greenhouse men serious concern. The use of unsuitable varieties and poor strains, has caused great loss of time and money and the grower cannot afford to take unnecessary chances of crop failure through the use of poor seed. Fortunately, considerable progress has been made in the development of better seed stocks of the more important vegetable forcing crops and as a contribution to this work I wish to briefly call your attention to some work done by the Office of Horticultural and Pomological Investigations, of the United States Department of Agriculture.

WORK WITH CAULIFLOWER

The work with this vegetable was started about 1908 by Professor W. W. Tracy, Sr., with seed secured from commercial sources and sold as Erfurt's Dwarf Forcing. The seed gave a crop of very mediocre quality, but selections were made and a very satisfactory strain was built up. This work was carried on by Professor Tracy and Dr. D. N. Shoemaker, both connected with

this office, assisted by Mr. August Mayer, in charge of the Arlington Farm greenhouses.

In 1918, this stock was used as a starting point in the work done by the author and his associates*. A preliminary crop was grown in the autumn of 1918 for the purpose of studying the best methods of handling the crop in the greenhouse which was a vegetable house 35 by 100 feet with 30 inch concrete side walls, 7 foot eaves, a 30° pitch roof, and without benches. In the spring of 1919, another crop set 20 by 20 inches apart was grown, a yield of 1409½ pounds being secured from 952 plants. Selections were made from this planting and the seed crop matured in large pots to which the selections were shifted when the main crop was harvested. The seed secured from these selections was grown in the same house in the spring of 1920. From the 504 plants grown in this crop, 461 marketable heads weighing 681 pounds were secured. Ten selections were made and allowed to mature their seed crop in the place where grown. The seed from these ten plants was planted December, 1920, in a like number of increase plants. One of these gave a crop with a remarkably short period of maturity while two others gave highly desirable marketing types. These three strains are being continued in our present work. Seed from these ten selections is available in small quantities for the use of investigators who might care to use it.

LETTUCE

In this work the original seed was a commercial strain of Grand Rapids lettuce and the first crop was grown in the soil fertility greenhouse at Arlington Farm, during the season of 1918-19. The crop was irregular and poor, but a few plants of good type were found, and under the direction of Mr. Mayer these were saved for seed. Only one of these plants was used as the foundation stock for the present work. During the season of 1919-20 a crop was grown from this seed and 15 of the best plants selected, potted and matured seed in isolation from each other. But ten of these plants were retained for further work. This seed was planted in increase plats in the fall of 1920 and additional selections made. All have been rejected except two, one being a fine curled, slightly yellowish green lettuce, very uniform and upright in habit of growth. The other is a coarser leafed type of a dark green color it also having an upright habit of growth. Seed from the best plants of these selections is now being grown and both strains are true to type. A limited amount of this seed also is available.

TOMATOES

The selection work on tomatoes began during the winter of 1917-18 and although several varieties have been worked on, the major portion of our efforts has been devoted to two of the English forcing varieties, Sterling Castle and Sunrise. The results discussed here deal with these two varieties only.

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* Credit is due Mr. C. J. Hunn, Mr. W. J. McGervey and Mr. August Mayer for assistance in carrying out the details of the work outlined in this paper.

The original seed was secured from commercial sources and selection work alone has been carried on. In making the selections all desirable characters such as vigor, freedom from disease, and trueness to type, were taken into consideration. The present stock is seed of the fifth generation and is far superior to the original stock. In the earlier crops, the best yields secured from individual plants were a little under five pounds. With the present stock, yields as high as twelve pounds per plant are being secured.

Sterling Castle is characterized by plants with rather delicate foliage, with weak petioles which allow the leaflets to droop close to the stem. The foliage is not markedly resistant to mosiac, but very resistant to leafspot, (*Septoria lycopersici*). The clusters are large with from twenty to thirty tomatoes on each cluster. The tomatoes are small in size running from eight to twelve to the pound.

The stock of Sunrise now in our possession is much superior to the Sterling Castle as the plants are very vigorous with broad outspreading foliage, and heavy stems. The tomatoes are borne in clusters bearing from eight to ten. Time will not permit the giving of detailed figures showing the yields secured from these improved strains, but the results secured are very encouraging and indicate that much can be accomplished within a short time in the development of better strains of greenhouse tomatoes. Morever, the work is so easily carried on that it is practicable for the average grower. We would be glad to supply seed of these strains to anyone interested in carrying on such work.

Apple Varieties Which Have Made the Best Parents

By R. WELLINGTON, *Experiment Station, Geneva, N. Y.*

A report on apple varieties which have made the best parents on the grounds of the New York Agricultural Experiment Station must at its best be of preliminary nature. Many crosses have not fruited and others have just commenced to bear fruits on an occasional tree. In every case where not over ten trees have borne fruit, the cross has not been considered.

To obtain a fair criterion of the value of each variety in transmitting desirable characteristics, the progeny of each cross has been classified into three groups; namely, good, mediocre and poor. In addition, the number and percentage of those seedlings deemed worthy of propagation for further trial is given. All seedlings reported upon in Bulleltin 350 have been omitted.

Performance of First Generation Apple Crosses

Cross	Good	Mediocre	Poor	Total	Propagated	Per cent propagated
Boiken x Gravenstein	1	7	3	11		
Boiken x Grimes	3	16	3	22		
Grimes x Boiken	7	63	21	91	1	1.1
Boiken x Wealthy	8	42	14	64	2	3.1
Wealthy x Boiken	5	75	12	92		
Canada Baldwin x Jersey Blue	2	18	9	29		
Jersey Blue x Canada Baldwin	3	15	12	30	1	3.3
Deacon Jones x Delicious	34	43	9	86	9	10.5
Delicious x Deacon Jones	13	19	8	40	4	10.0
Deacon Jones x Wealthy	11	24	4	39		
Green Newtown x Northern Spy	5	5	1	11	1	0.9
Jersey Blue x Jonathan	7	9	1	17		
Jersey Blue x Louise	8	30	14	52	1	2.0
Louise x Jersey Blue	3	9	2	14		
Jersey Blue x McIntosh	9	5	3	17	1	5.9
McIntosh x Jersey Blue	5	10	1	16	3	18.8
Jonathan x Rome	5	8	2	15	1	6.7
Rome x Jonathan	1	13	1	15		
Lawver x McIntosh	10	13	2	25	1	4.0
McIntosh x Lawver	9	11	2	22		
McIntosh x Yellow Transparent	12	30	15	57		
Yellow Transparent x McIntosh	16	61	17	94	3	3.2
Montgomery x Red Astrachan	12	45	9	66	1	1.5
Montgomery x Yellow Transparent	14	59	25	98		
Yellow Transparent x Montgomery	13	83	35	131	2	1.5
Oldenburg x Yellow Transparent		7	5	12		
Red Canada x Delicious	32	67	24	123	4	3.3
Red Canada x Yellow Transparent	5	52	7	64		
Yellow Transparent x Red Canada	3	8	1	12		
Wealthy x McIntosh	28	37	9	74	4	5.4
Winter Banana x Delicious	12	15	6	33	3	9.1

By studying the table it is readily seen that most of the varieties are practically worthless in giving desirable progeny, while a very few are outstandingly good. Among those varieties that give undesirable progeny may be included Boiken, Grimes, Canada Baldwin, Jersey Blue, Wealthy, Deacon Jones, Montgomery, Yellow Transparent and Red Canada. Some of these varieties, however. possess the ability to transmit one or more desirable characters, as size, productiveness, earliness, etc. All of them evidently lack the ability to impart quality in a high degree and when this character is wanting, the seedling is worthless. Among those varieties that give desirable progeny there are two outstanding varieties; namely, Delicious and McIntosh. Wherever either of these varieties is used as parents, no matter how inferior may be their consort, many of the resulting progeny are good and a few are worthy of further propagation. To be worthy of propagation indicates that they possess one or more characters superior to the standard sorts. Just what proportion will become standard varieties, only time will tell, but the few of us who have seen them, possess unbounded confidence in their ability to win a niche in the horticultural field.

The Role of the European Grape (Vitis vinifera) in the Origination of American Varieties

By H. B. TUKEY, *Experiment Station, Geneva, N. Y.*

THE early visitors to these shores, when they saw the native grapes in such abundance, were not slow in recognizing the possibility of a great wine industry in the New World. Again and again the attempt was made to grow the European grape, *Vitis vinifera*, but without success. No effort was made to develop the native grapes—they were looked upon as too poor in quality and altogether too worthless to bother with.

Two centuries passed and then came the variety which was to revolutionize the grape industry of America, the variety which was to turn the thought of men from the grape of the Old World to that of the New World. This was the famous Cape grape or Alexander. Then followed the Catawba—another so-called native grape— and the Concord, a supposedly pure wild Labrusca, to become the "grape of the millions" as Horace Greeley so aptly stated it.

All the common knowledge of the day has stressed the point that it was the native grapes that put the grape indusry in America on its feet; and the early pioneers in grape growing have been criticized because they held too stubbornly to their Old World principles and did not develop what was already growing profusely about them. And so the importance of the European grape in the origination of American varieties of grapes has been frequently underestimated.

PROPORTION OF AMERICAN VARIETIES CONTAINING VINIFERA

There are 206 varieties of grapes listed as major varieties in The Grapes of New York by U. P. Hedrick assisted by Booth, Taylor, Wellington and Dorsey. Of the 206 listed, 204 are American varieties and it is with this number that we shall treat.

Out of these 204 American varieties considered of major importance for one reason or another, 111 are listed as containing blood of *V. vinifera,* 20 as perhaps containing it, and 73 as containing none of this species. That is 54 per cent, from their characters or from their known ancestry, are listed as undoubtedly containing Vinifera blood; 10 per cent as possibly,but not certainly, containing it; and 36 per cent as containing none of it, but being merely developments of the species found in America.

If we go one step further and divide the grapes according to quality into two groups "below good" and "good and above" we can prepare a table as follows:

TABLE I

Relation Between Vinifera Ancestry and Quality

Rating	Number in class	Number of these containing Vinifera		Vinifera ?		No Vinifera	
			Per cent		Per cent		Per cent
Below Good	67	14	21	7	10	46	69
Good and above	137	98	71	12	9	27	20

The increased preponderance of varieties containing Vinifera blood is very marked as quality increases and that is just what we should expect, for American species of *Vitis* are notorious for their low quality. And yet there are what at first appear to be exceptions to the rule. The grapes containing blood of *Vitis aestivalis Bourquiniana* are far above the average in quality —Berckmans, Moyer, Devereaux, Herbemont, Lenoir, Cunningham and related varieties comparing favorably with the European grapes. What, then is *V. aestivalis Bourquiniana.*

THE STATUS OF *Vitis aestivalis Bourquiniana.*

It was T. V. Munson who removed from *V. aestivalis* (the summer-grape) the group of cultivated varieties characterized by Herbemont and Devereaux and placed them in a separate division which he designated *V. Bourquiniana* after the Bourquin Family of Savannah, Georgia, which he held to have been the importers.

Viala and Vermorel (3)* in Traite General de Viticulture say: "Herbemont was produced directly according to the deductions of Millardet, who is our authority in the matter, as a hybrid of Aestivalis crossed with Vinifera and Cinerea. It is not possible that this crossing occurred in America since the Herbemont had been known in Southern Texas (from which it spread into the rest of the country) for more than a century, that is to say before they had in that section any varieties of European origin. On the other hand it is said that there were very early importations of American vines into Madeira. If this is correct, the accidental hybridization would have been quite possible in the Madeira vineyards between the native and the American varieties and the hybrids resulting from these natural crosses would quite easily have been introduced into the southern portion of the United States by emigrants".

Bailey (2) writes of this species: "A domestic offshoot, represented in such cult. varieties as Herbemont and Le Noir...... A mixed type much cult. S. It is probably exotic, but may have been modified by hybridization. Probably to be associated botanically with *V. vinifera*".

RECONSIDERATION OF AMERICAN VARIETIES CONTAINING VINIFERA

This throws a different light upon the matter and revision of Table I becomes necessary. If now instead of using the two

*Reference by number to literature cited.

groups of that table we make six groups according to quality—namely: "below good", "good", "good to very good", "very good", and "best", and classify the 204 varieties under these heads, we derive Table II.

TABLE II

Relation Between Vinifera Ancestry and Quality, Corrected for V Bourquiniana

Rating	Number in class	Number of these containing Vinifera		Vinifera ?		No Vinifera	
			Per cent		Per cent		Per cent
Below good	67	17	25	8	12	42	63
Good	62	41	66	8	13	13	21
Good to very good ..	51	42	82	14	8	5	10
Very good	17	15	88	1	6	1	6
Very good to best ..	4	4	100	0	0	0	0
Best	3	3	100	0	0	0	0

From this it will be readily seen that out of a total of 24 varieties rated "very good and above" there are only two that do not certainly contain Vinifera. One of these is James, and it is apparently pure *V. rotundifolia* (the southern fox grape), with no mixture of other species. It is impossible to grow this variety on the station ground at Geneva and no crosses containing it have been made, so that no material is available to the author throwing any light upon its ancestry. Apparently it contains no Vinifera blood. The other is Alexander Winter, and this is listed as one which may possibly contain some Vinifera. From the description in The Grapes of New York it is characterized as "Flesh tender, vinous, with indications of Vinifera parentage ......Vine and foliage indicate Labrusca parentage, but the fruit suggests a mixture of Vinifera". Aside from this, however, selfings at the Geneva Station indicate that the *possible* Vinifera may be an *actuality*. But in order to get at the indications of Vinifera we must understand what characters are peculiarly those of that species.

CHARACTERS ATTRIBUTED TO *V. vinifera*

The characters attributed to *V. vinifera* are, to a certain extent, the opposite of *V. labrusca*. For example *V. vinifera* is high in quality while *V, labrusca* is low; the berries in the former are round or oval while in the latter oblate or inclined to oblateness; the former adhere strongly, the latter shell badly; the one keeps well, the other keeps poorly; the one is tender, the other hardy; *V. vinifera* is susceptible to black-rot and mildew, *V. labrusca* less so; the former is late in maturing its fruit and the latter early; the flesh of the one is uniform throughout and the flavor is characteristically "vinous", while the flesh of the other is watery and tough and the flavor is noticably "foxy".

V. Vinifera imparts to hybrids weakness of vine along with improved quality of fruit. It leaves its mark upon the fruit,

however, more than it does upon the vine. And though a vine may be weaker and more tender because of containing Vinifera blood, yet that blood is not so easily detected in the vine as in the fruit. The ovalness of the berry seems to be one of the most reliable indexes to Vinifera ancestry.

Results of Selfing Alexander Winter

The berries of Alexander Winter are round, yet out of five selfed seedlings of this variety one bore berries that were round and four bore berries that were round to round oval; one was slightly meaty and four were midseason to late midseason. It is impossible in a paper of this length to go further into detail; the fact is, however, that the offspring of Alexander Winter emphasize even more strongly than the parent stock, the probability of Vinifera blood.

And so we conclude that James alone of the 24 varieties rated as "very good and above" does not contain Vinifera. It is well to note in passing that James besides offering no record or means of inquiry into its ancestry is the lowest of the three grades "very good", "very good to best", and "best".

Further Consideration of Relation Between Vinifera Ancestry and Quality

Returning now to the total number of grapes rating "good or above" in quality, we have the following grouping:

1. Certainly containing Vinifera—105, (6 of which are included here because they contain Bourquiniana—namely, Berckmans, Devereaux, Herbemont, Jaeger, Lenoir, Moyer and Nectar).

2. Possibly containing Vinifera—13—namely, Adirondac, Alexander, Alexander Winter, Alice II, Brown, Cayuga, Creveling, Early Victor, Empire State, Hayes, Marie Louise, MarionII and Martha.

3. Supposedly contaning no Vinifera—19

(a) Concord and supposedly of Concord parentage—13—namely, Antionette, Chautaqua, Colerain, Concord Ester, Glenfield, Hicks, Hosford, King, Pocklington, Rockwood, St. Louis and Worden.

(b) Others—6—namely, American, Eureka, Gold Coin, James, Noah and Vergennes.

Examination of those possibly Vinifera: The 13 grapes in Class 2 listed as possibly containing Vinifera may be briefly examined.

Adirondac: "On (1) account of its resemblance in vine to Isabella it is supposed by many to be a seedling of that variety...... The claim is often made for this variety that it is nearer the Black Hamburg in quality than any other American grape....Vine.... injured in severe winters, subject to attacks of mildew in unfavorable seasons."

Alexander: This is the Cape grape which Dufour felt strongly was a European kind. The berries are oval, the season is late. "Its (1) place of origin (in the vicinity of an old vineyard of Euro-

pean kinds) would indicate that there was an opportunity for hybridization to take place''.

Alexander Winter: Previously discussed.

Alice II: "Flesh (1) tender, vinous,......This is a Labrusca with a few characters which indicate Aestivalis and Vinifera blood."

Brown: " 'Brown's (1) seeding came up.....near an Isabella vine....The statement is further made that Charles Downing examined the vine several times and said 'there was no doubt that it was a seedling of the Isabella.' " The berries are roundish to slightly oval.

Cayuga: This is a seedling of Adirondac with berries much like Isabella in shape. If Adirondac is a seedling of Isabella then it follows that Cayuga is of Vinifera parentage.

Creveling: It is of the Isabella type with oval berries.

Early Victor: Although the parentage is not definitely known this grape contains a strong dash of something other than Labrusca and the supposition is that it is a Labrusca-Bourquiniana cross.

Empire State: "General (1) supposition is that it is a hybrid between Clinton and some variety of Vinifera, the character of the fruit in particular indicating such breeding."

Hayes: "The (1) intermittent tendrils and certain characters of the seeds indicate that there is some species besides Labrusca, possibly Vinifera."

Marie Louise: "Berries (1) roundish to oval.. .good to very good in quality."

Marion II: Resembling Isabella, berries round inclined to oval.

Martha: Good to very good in quality, with characters suggesting Vinifera.

While it would be unwise to say that in each case there is certainty of Vinifera admixture, yet it can be said with confidence that there is not one of these varieties which can be held as destitute of some infusion of Vinifera blood.

Concord and its seedlings: The seedlings of Concord are interesting in themselves. There are those who believe that Concord is other than the pure Labrusca that it is commonly thought to be. In speaking of *V. labrusca* T. V. Munson says: "Its (4) native vines of New England states endure cold well, but great heat and drouth poorly; little resistant to phylloxera; downy mildew does not affect it much nor does black-rot often attack its pure native forms, though severe in Concord and its seedlings generally, and very destructive of all hybrids of it with *Vitis vinifera*." Again he says: "The Concord, (4) though chiefly of Labrusca blood, clearly shows in itself and many of its seedlings a trace of Vitis Vulpina, and it is to that cause probably, they owe their better quality."

Viala and Vermorel record: "The (3) Concord is very resistant to the mildew, to the oidium, and to the anthracnose, but it is on the other hand, very susceptible to the black rot......."

Moreover, many of the white offspring of Concord are superior to it in quality, such as Antionette, Colerain, Hayes, Marie Louise, and Martha, suggesting the possibility that a white Vinifera was one of the parents of Concord.

From selfings of Concord made at the Geneva Station, 28 vines have been grown of which 23 have been described. From these records we gather notations of "better than Concord," "like Concord only sweeter", "Sweet, Worden flavor". One is rated "very good" in quality, one is late, eight have round berries, two have berries round to oval, one is called "vinous," one is "meaty," and three are strongly adherent. Concord has upright stamens, and yet there is no certain evidence that there are hermaphrodite flowers in any of the American species of Vitis, although this form is common in the European species. And so we see that even Concord is suspicioned of contamination with *V. vinifera*, and if this is so then the 13 of Concord parentage contain Vinifera blood.

Others supposedly containing no Vinifera: *Of those listed as* not Concord seedlings and as not containing Vinifera, Vergennes undoubtedly does contain it. It could easily be taken for a Roger's Hybrid so closely does it resemble one. In its reddish color, leaves usually not lobed, thick, tough skin, beaked seeds, and long keeping in common storage, it acts like one of these hybrids. The berries, moreover, are oval to roundish and the adherance is strong.

Eureka, Gold Coin and Noah are three others listed as containing no Vinifera. Eureka is said to be a seedling of Isabella resembling the parent very closely; Gold Coin is a cross between Norton and Martha and has berries roundish to slightly oval; and eight selfed seedlings of Noah give one with roundish to slightly oval berries, one with oval berries, one "vinous" and one "very good" in quality. America and James alone of the 137 rating "good and above" show, from the evidence at hand, no traces or suspicions of Vinifera.

Relation Between Keeping Quality and Vinifera Ancestry

The long keeping quality of Vinifera grapes has long been recognized as contrasted with the short keeping quality of grapes of the American species. A table developed from the storage records kept at the Geneva Station and recorded in Geneva Bulletin 408 (5) illustrates this point.

Table III

Keeping Quality and Vinifera Ancestry

Weeks in common storage	Number in class	Number of these containing: Vinifera		Vinifera ?		No Vinifera	
			Per cent		Per cent		Per cent
4-10	56	21	37.5	7	12.5	28	50.0
11-15	36	23	64.0	3	8.0	10	28.0
16-20	24	20	83.0	2	8.5	2	8.5
21-25	12	10	83.0	1	8.5	1	8.5
26-31	9	8	89.0	0	0.0	1	11.0
Average of all	137	82	60.0	13	10.0	42	30.0

This table records the parentage of the varieties as they are given in The Grapes of New York with the exception that grapes containing Bourquiniana are listed among those of Vinifera blood. Vergennes alone of the nine varieties keeping more than 25 weeks in common storage, is listed as containing no Vinifera; and we have shown reason to believe that Vergennes does contain Vinifera blood.

Increasing Importance of Vinifera

In the past the work of producing grapes of merit has for the most part centered around selections from crosses of varieties of American origination, or from crosses of one of these varieties with a European sort. Not to the writer's knowledge have the European kinds been intercrossed and the resultant progeny selected for American conditions.

Naturally, *V. vinifera* has been selected for centuries for European conditions. Grapes of that species did not at first thrive in this country for various reasons, but now that we have adequate means of combating black-rot and mildew, and understand the growing of Vinifera grapes upon roots resistant to phylloxera, there is no reason why they cannot be grown successfully as they have been at the Geneva Station.

Moreover, some Vinifera varieties are hardier than others. Petite Syrah, for example, while not hardy, is much hardier than the Chasselas group of Viniferas. Again some of the American hybrid grapes are remarkably high in Vinifera blood, and show Vinifera characters in both vine and fruit to a surprising degree. Such grapes as Mills, Downing, Urbana, and a great number of station seedlings show a high amount of Vinifera. In fact, one seedling has been produced which resembles the Flame Tokay.

With these points in mind the Geneva Station has proceeded to make crosses between the European varieties and has the past season produced several thousand seeds from which it is hoped some desirable progeny may be selected.

Conclusion

In conclusion, it is well to note that even the very grapes that were supposed to be the pure native varieties which turned the eyes and thoughts of the pioneers of the grape industry in America away from the Old World grape....namely, the Alexander and the Catawba, are included in those which unquestionably contain Vinifera blood.

Perhaps in the future it were better to state that it was the improvement of the American native varieties by the addition of European blood that gave the American grape industry its impetus.

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Results in Fruit Breeding at the Experimental Farm, Ottawa

By W. T. MACOUN, *Central Experimental Farm, Ottawa, Canada.*

The breeding of new varieties of fruits has been an important feature of the work of the Horticultural Division of the Dominion Experimental Farms since the Experimental Farms were established in 1887. The late Dr. William Saunders, Director of Experimental Farms, was one of the first fruit breeders in Canada, beginning his work in 1868. The fruits he worked with at first were the black, red and white currant, gooseberry, raspberry, blackberry and grape. All the promising material which had originated with him at London, Ontario, was sent to Ottawa in 1888, and he continued the work of crossing and selection there.

Currants.—Some very valuable varieties of black currants were originated by Dr. Saunders, which the Horticultural Division has disseminated, and which are proving better than other varieties, being more productive. They are also hardier than some of the other sorts. Those which have done best in different parts of Canada are Kerry, Climax, Magnus, Saunders, Topsy, and Ontario. These have all been described in Bulletin 94 on Bush Fruits and previous publications of the Experimental Farm Series. *Gooseberries.*—The Josselyn gooseberry, formerly called Red Jacket, was originated by Dr. Saunders and introduced many years ago, and is now widely known. Pearl also has been introduced a long time, but is too much like Downing to be readily recognized. Other varieties which have proven more productive than Downing, and which are being introduced, are Charles, a cross between Houghton and Roaring Lion with fruit larger than Downing; Mabel of unknown parentage as large as or a little larger than Downing, and yielding more than Downing; Silvia of unknown parentage, a very heavy cropper, succeeding particularly well in the Province of Quebec. These are all described in Bulletin 94.

Raspberries.—Many crosses were made by Dr. Saunders between the black cap raspberry and the red raspberry. His first work was done in 1870, when the Doolittle black cap was pollenized by Philadelphia, a red sort. From this combination were obtained 24 plants, all of which would root from the tip and the year old canes layered very readily. Some of them also proved suckering varieties. The fruit was dark purple and more acid. None of these hybrids proved sufficiently promising to introduce. Though a few were very productive, they were unattractive in color. Seedlings were also raised from Shaffer, and of these, one the Sarah, a purplish red suckering variety of excellent flavor, has proved a desirable sort for home use for lengthening the season, being quite late. At Ottawa it has not proven sufficiently productive to be considered a valuable commercial sort.

Count, a red seedling of Biggars Seedling, which was a red

sort, is a very promising early sort, and has been introduced. It is the most productive early variety tested at Ottawa.

Brighton, another early variety of unknown parentage, is very hardy, and, next to Count, is the most productive early sort, taking an average over a long period.

These varieties are described in Bulletin 94.

Later breeding work with currants, gooseberries, and raspberries is in progress in the Horticultural Division, and new sorts of merit will no doubt, be introduced later on.

Strawberries.—Most of the breeding of strawberries until the last few years was with open pollinated seed, but some very promising varieties from cross pollinated plants are now under test. Of the open pollinated sorts, those which have been introduced because found after thorough test to be better than other sorts in certain respects, are Portia (Imp), seedling of Wm. Belt, and the best berry for canning of all sorts that have been tried. It is good in quality, handsome in appearance, and productive. The foliage of this sort is very fine.

Hermia (Per.), seedling of William Belt, productive, attractive, and good in quality.

Cassandra (Per.), a Bubach seedling, very handsome, productive.

Mariana (Per.), a Bubach seedling, productive, handsome in appearance, and above medium to good in quality.

The names of Shakespeare's heroines are given to seedlings originated in the Horticultural Division.

Grapes.—The most promising variety of grape originated by Dr. Saunders is the Kensington, a white sort, a cross between Clinton, female, and Buckland Sweetwater, male. This variety is a good one for home use where the season is long enough, but at Ottawa the season is too short for it. The skin is too tender for a commercial variety. The Craig is a variety originated in the Horticultural Division, Ottawa, by crossing Florence, a very early Labrusca variety, with Potter. The Craig is an early productive black variety of good quality and is being propagated for dissemination.

Plums.—The breeding of plums at Ottawa until comparatively recent years consisted in raising seedlings of pure Americanas. Many good varieties were originated and several named. No marked advance was, however, made over the varieties which had been already introduced. It having been found that Prunus nigra made a stronger tree, not so easily broken down, and considering the fact that hardy varieties of plums were lacking at a time when the market was short of plums, and that the skin of the fruit was thinner than the Americanas, the Nigra plum has in more recent years been used as a parent in perference to the Americanas. Having discovered an extremely early variety of Nigra, seedlings were grown from it, and from this lot two have been named, Ottawa and Rideau, both being very early and larger than the parent. A richer flavor is needed in the Nigra plums, and in crosses made with Prunus triflora it is hoped to obtain as

much success as other workers have obtained who have used this species.

Pears.—No striking advance has yet been made with pears. Hardy Russian varieties have been crossed with the most blight-resistant of the commercial varieties, and a large number of these should fruit next year.

Cherries.—Comparatively little progress has been made with cherries. One of the most interesting lines of work is the growing of seedlings of Prunus tomentosa, from which the most productive and largest fruiting sorts are being selected. These are now in the F_2 generation.

Apples.—The apple breeding at the Experimental Farm, Ottawa, has been done for three main purposes. 1st—To extend the areas in Canada where apples of good marketable size can be grown successfully; 2nd—To obtain hardier winter apples for the colder parts of Canada where apples can be grown commercially, but where there are at present no good winter sorts grown; 3rd—To obtain summer and fall apples of better quality than those now generally grown.

Work was begun in 1890 by sowing seed obtained from Northern Russia. Some three thousand trees were grown, a large proportion of which fruited, and a few of the best were named and sent out for test to the prairie provinces in the hope that something hardy enough for the prairies would be obtained among them. None of these have proved hardy there, but out of this lot one variety called Rupert, a greenish yellow variety, is earlier than Yellow Transparent and better in quality, and is being multiplied for distribution as a variety especially adapted for home use.

The wild Siberian crab apple (Pyrus baccata), having proved hardy on the Canadian prairies, it was used as the female parent in cross-breeding begun in 1894, many Russian and American varieties being used for male parents. The largest fruit obtained from these first crosses was about 1½ inches in diameter, quite crab-like. A number of these were named and sent to many parts of the prairies for test. After a thorough test, two of these, the Osman and Columbia, appear to be the hardiest, and will live and bear fruit in some of the coldest and most exposed places on the prairies. The best of the first crosses were re-crossed with the apple in 1904, and from this work fruit was obtained 2½ inches in diameter, most varieties being quite crab-like in character of flesh. The best of these are now being tested on the prairies to determine their hardiness. Some of the most promising are Rosilda, Wapelia, Angus, Elkhorn, Trail, Piotosh, Printosh, and Redman.

There is a great need for hardy winter apples over a wide area in the colder parts of Canada where apples are grown commercially, and it has been the endeavor of the Horticultural Division since 1895 to obtain such ones. Many late keeping apples have been originated which are now being tested for hardiness, and while they are not as good in quality as is desired, they are

better than anything available before. Some of the most promising if these are crosses between Antonovka and Milwaukee, the firm flesh of the Antonovka combined with the fair keeping quality of the Milwaukee having given longer keeping apples of firm flesh than either of the parents.

In 1898 seed was sown at Ottawa of the varieties of winter apples which had fruited there in the hope of obtaining some hardier winter sorts. The following are the varities: Northern Spy, Lawver, Salome, Gano, Ben Davis, American Golden Russet. Other varieties of earlier season are: McIntosh, Shiawassee, Fameuse, St. Lawrence, Swayzie, Wealthy, and Winter St. Lawrence, and more recently other varieties were used. Many hand pollinated crosses have been made where other varieties were used. About 2,000 varieties have fruited as a result of all this work, the best of which having been named, and a few of which are now being propagated so that they may soon be supplied by the hundred.

Melba—Season, August .... McIntosh seedling
Joyce—Season, Early September .... McIntosh seedling
Pedro—Season, September .... McIntosh seedling
Patricia—Season, October .... McIntosh seedling
Lobo—Season, October and November .... McIntosh seedling
Mendel—Season, Winter .... Wealthy Seedling

The following winter seedlings of Northrn Spy are all good in quality and somewhat of the Northern Spy flavor. They came through the test winter of 1917-18, but another test winter is required before their relative hardiness will be certain. If they prove hardy enough they will be distinct acquisitions to the list of apples for the colder districts where apples are grown commercially. The varieties are as follows: Bingo, Donald, Elmer, Emilia, Niobe, Rosalie, Sparta, Spiro, Wilgar. Detailed descriptions of these and the McIntosh seedlings have been published in the reports of the Experimental Farms.

Results of Selection in the Alaska Pea *

By JOHN W. BUSHNELL, *University Farm, St. Paul, Minn.*

THE Alaska Pea (*Pisum sativum*) is extensively grown for commercial canning. Its extreme earliness, moderate height, fruiting habit and small seed, adapt it to machine methods of large scale production. As observed under field conditions in Minnesota, the first flower is uniformly borne at the seventh or eighth node, about thirty centimeters above the ground. Each node above this produces a flower-stalk bearing a single pod. At the time of harvesting, when the peas in the lowest pod have attained their full size, the plant is typically about eighty centimeters tall, bearing four to six filled or partially filled pods.

The variety was "introduced about 1881 as Laxton's Earliest of All by Mr. Thomas Laxton of Bedford, England" (Stokes 1921). Although forty years old, it is at present a prominent standard variety, and strains from different sources tested at University Farm in 1921 appeared very similar in all plant characters.

The literature on the genetics of peas has been summarized by White, (1917). He points out that *Pisum* is normally self-fertilized, and states "all horticulturists and breeders remark on the extreme constancy of pea varieties, some of which have been in existance for at least a quarter of a century without showing any striking modifications. Several of the varieties mentioned by Darwin are still in existance to-day, and very little changed, so far as one may decide by the descriptions written in his day." Further, "most of our new varieties of peas are obtained through crossing, there being so little variability in varieties by which one may bring about improvement through selection." The only instance of simple selection White reports is the work at the Svalöf Station, where improved strains were isolated by selection from impure varieties.

From these facts, lt would be predicted that a variety of peas as uniform as the Alaska would be a pure line, or a mixture of very similar pure lines. However, as there was no direct evidence on the genetic purity of this variety, a project was started at the Minnesota Experiment Station to study this question and to attempt to isolate higher yielding strains by single plant selection.

The work was started in 1914 by R. Wellington, then in charge of the vegetable investigations. Several strains of Alaska were secured from retail seedsmen, and a number of single plant selections made that year. During the next three years the seed stock was increased, and data taken on the dry seed when harvested. Wellington resigned in the spring of 1918, and due to unavoidable disruption of the experimental work during the war, the problem was postponed except for plantings to maintain the supply of viable seed.

In 1920 the problem was turned over to the writer, and pre-

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liminary observations were made on these selected strains in comparison with a commercial strain furnished by one of the Minnesota canning companies. These preliminary observations showed small differences in the number of pods per plant in the different strains. It, therefore, seemed advisable to conduct a more critical test in 1921, comparing the selected lines with a number of commercial strains.

Eight of the strains from the single plant selections of 1914 that had been studied in 1920 were considered worthy of testing. Through the courtesy of the Minnesota Valley Canning Company the following list of concerns dealing in pea seed on a large scale where secured and each furnished generous samples of their stock of Alaska:

John H. Allan Seed Co., Sheboygan, Wis.
Evert B. Clark Seed Co., Milford, Conn.
N. B. Keeney and Son, Le Roy, N. Y.
Jerome B. Rice Seed Co., Cambridge, N. Y.
Rogers Bros. Seed Co., Chicago, Ill.

In addition a number of unknown smooth seeded types collected from various sources were included, but these all proved to be later maturing than the Alaska and were discarded. They are indicated on the field plan by "XXX".

As the pea grows and ripens very rapidly during the period that the pods are "filling," it was deemed necessary to limit the plot to an area that could be accurately harvested in a single day. To secure the most reliable results from this limited area the plot was laid out with rows only a rod long, with each strain triplicated, as shown in the accompaning field plan. The long rows three feet apart were made up of seven adjacent rod rows. The plants in the row were spaced eight inches apart.

The objection might be raised that such a spacing will give results that cannot be compared with data from strains grown under the intensive cropping system of the canneries where four bushels per acre are planted with a grain drill. However, it seemed preferable to carry on these first critical tests in a manner that would allow a detailed examination of the individual plants.

The seed was planted April 18. About once each week after the plants were up the individuals were inspected to detect evidence of mixture or genetic segregation. As a whole the strains in the field grew uniformly, blossomed simultaneously, and appeared very uniform as the pods filled. The effect of the spacing of the plants became evident as the pods formed. Under field conditions the Alaska is typically a single stem bearing four to six pods, one at each fruiting node. Under the conditions of this experiment a large proportion of the plants sent out two or three branches at the ground line. Many of these branches bore one or two pods. Again there were frequently two pods on a peduncle. This branching and production of paired pods was found occurring consistently in all the strains throughout the entire plot.

In harvesting, data were taken that as far as possible would indicate the relative value of the strains for commercial canning.

With this in mind, the plot was harvested June 20th, just as the oldest pods gave signs of hardening.

The picking was carefully done by hand, all the pods being gathered that were large enough to be shelled by the modern viner used at the pea canneries. The pods from each rod row were counted, and those from the last replication, series C, were shelled. Each of these shelled lots were graded by hand according to the standard sizes:—No. 1—9/32″, No. 2—10/32″, No. 3—11/32″, No. 4—12/32″ (Bitting 1909)—with those larger than 12/32″ included in grade 4. In the accompanying table these data are presented on the basis of yield per plant, both for the number of pods and the weight of peas.

Although the differences between the strains are more or less consistent it might seem possible to account for them by soil differences. To show that there were no marked high yielding areas in the field the field plan is presented with the average number of pods from each rod row placed below the strain number

Strain Test of Alaska Peas—University Farm, 1921

Strains	Location	Plants	Number of Pods	Average	Average Yield per Plant: Shelled and graded peas in grams				
					4	3	2	1	Total
Minnesota No. 1	A	23	6.0						
	B	22	5.8						
	C	22	6.7		4.8	2.6	.7	.9	9.0
				6.2					
Minnesota No. 5	A	23	8.3						
	B	25	7.4						
	C	21	6.7		4.9	2.0	1.3	1.4	9.7
				7.5					
Minnesota No. 6	A	24	8.4						
	B	23	7.2						
	C	21	8.2		6.3	3.5	1.7	1.6	13.0
				7.9					
Minnesota No. 8	A	24	10.0						
	B	25	8.3						
	C	24	8.5		5.6	3.4	1.6	1.5	12.1
				8.9					
Minnesota No. 9	A	24	11.7						
	B	24	10.1						
	C	23	9.7		4.4	3.7	2.0	2.3	12.4
				10.5					
Minnesota No. 12 ...	A	23	9.6						
	B	23	9.9						
	C	22	8.0		5.9	3.0	2.2	1.3	12.4
				9.2					
Minnesota No. 14 ...	A	25	8.8						
	B	24	8.2						
	C	24	6.6		6.7	2.4	1.4	1.0	11.5
				7.9					
Minnesota No. 19 ...	A	22	7.7						
	B	16	7.1						
	C	22	8.2		5.6	3.0	1.7	1.5	11.9
				7.7					
Allan Seed Co.	A	23	6.1						
	B	Accidentally lost							
	C	21	8.0		4.0	3.2	1.7	1.8	10.7
				6.8					
Clarke Seed Co.	A	25	6.9						
	B	25	8.6						
	C	25	6.8		4.8	2.8	1.5	1.1	10.2
				7.4					
Keeney and Son	A	25	7.0						
	B	25	6.7						
	C	25	6.2		3.0	2.5	1.9	1.6	9.0
				6.6					
Rice Seed Co.	A	25	7.8						
	B	24	8.9						
	C	24	7.3		4.1	2.4	1.6	2.0	10.2
				8.0					
Rogers Bros.	A	24	7.1						
	B	23	6.8						
	C	23	7.8		5.0	3.3	1.3	1.7	11.3
				7.2					

Field Plan of Yield Test

Yield of pods per plant placed below the strain name.
XXX indicates discarded strains.

A	Minnesota 1 6.0	Minnesota 5 8.5	Minnesota 6 8.4	Minnesota 8 10.0	Minnesota 9 11.7	XXX	XXX
A	Minnesota 12 9.6	XXX	Minnesota 14 8.8	Minnesota 19 7.7	XXX	XXX	Allan 6.1
A	Clark 6.9	Keeney 7.0	Rice 7.8	Rogers 7.1	Minnesota 1 5.8	Minnesota 5 7.4	Minnesota 6 7.2
B	Minnesota 8 8.3	Minnesota 9 10.1	XXX	Minnesota 12 9.9	XXX	Minnesota 14 8.2	Minnesota 19 7.1
B	XXX	XXX	Allan Lost	Clark 8.6	Keeney 6.7	Rice 8.9	Rogers 6.8
C	Minnesota 1 6.7	Minnesota 5 6.7	Minnesota 6 8.2	Minnesota 8 8.5	Minnesota 9 9.7	XXX	XXX
C	Minnesota 12 8.0	XXX	Minnesota 14 6.6	Minnesota 19 8.2	XXX	XXX	Allan 8.0
C	Clark 6.8	Keeney 6.2	Rice 7.3	Rogers 7.2			

It seems clear from an inspection of this field plan that the differences between the high yielding and low yielding strains can hardly be due to their location. In order to confirm this statement the probable error of the number of pods has been calculated by the pairing method of Wood and Stratton as modified by Hayes and Garber (1919). This calculation gives a probable error of a single row 7.2 per cent of the number of pods harvested, or 4.2 per cent for the average of three rows. Carrying this further, the probable error of a difference between two averages is 5.9 per cent of the mean yield, or, in terms of number of pods, about .5 pod. Thus number 9 with an average yield of 10.5 pods per plant exceeds the highest yielding commercial strain by 2.5 pods per plant, a difference of five times its probable error.

It may be concluded that single plant selections have isolated strains ranging in yield from number 1 with an average of 6.2-.27 to number 9 with 10.5 ± .44 pods per plant. And that under the conditions of this experiment strains 9, 12 and 8 outyielded the best of the commercial strains in number of pods per plant. In general the yield of shelled peas per plant confirms the results from the pod counts. The one exception to this is strain 6 with the highest yield of shelled peas. Strain 6 was the most mature strain and, therefore, a larger proportion of the shelled peas are of larger size giving a greater weight without an actual greater number of peas. The high yield of this strain is confined to grade 4.

A more important fact is to be emphasized in connection with the weights of the various grades of peas,—the higher yielding selections give practically the same distribution into the various grades as do the commercial strains. In the case of strain 9 the highest yield of the smaller grades of shelled peas was secured.

The general conclusion to be drawn from the preceding data is that distinct differences in yield have been found between strains that are very similar in other characteristics. In the opinion of the writer, these differences will be found to be correlated with the number of bearing branches, or the number of fruiting nodes bearing two pods, or possibly both. The question then becomes: Will these higher yielding strains of Alaska pea prove to be superior to the available commercial strains when grown under field conditions? This cannot be definitely answered from the data at hand.

The one important point these data do show is that strains derived from single plant selections in the Alaska pea possess measurable differences, differences of a genetic nature; and it is reasonable to expect that this genetic difference will result in measurable differences in yield when the strains are tested under field conditions.

Summary

Single plant selections in the Alaska pea, a normally self-fertilized crop, have given rise to strains that vary measurably in yield when grown in rows with the plants spaced eight inches apart. Of eight selections, three gave distinctly higher yields than the highest yielding of five commercial strains. As this method of

test permitted a much greater development of the individual plant than commonly occurs, it has not been demonstrated that these higher yielding selections will prove superior to the present commercial strains when grown under field conditions.

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Best Parents in Various Lines of Breeding Work Under Way at Ottawa

BY W. T. MACOUN, *Central Experimental Farm, Ottawa, Canada.*

AS the parents used in breeding work at Ottawa were, until quite recently, limited to but a few varieties of all the kinds of fruits worked with, except the apple, the results given in this paper are mainly those obtained with apples.

When the breeding work with apples was begun in the Horticultural Division at Ottawa in 1895, it was for the purpose of obtaining hardier and better sorts than those which were then available in the trade. The chief need, however, seemed to be a longer keeping apple of high color and good quality for the colder parts of Eastern Canada. The varieties of long keeping winter apples then being recommended for that part of the country were Ben Davis, American Golden Russet, Pewaukee, and Scott Winter. Since that time the Ben Davis has been found to be too tender. Pewaukee has also winter-killed and, while American Golden Russet and Scott Winter have suffered to some extent, also, they seem to be two of the hardiest long keeping apples available from nurserymen. Of varieties found in the trade, we now include in our list of recommended varieties, in addition to American Golden Russet and Scott Winter, the Bethel, which has been found as hardy a long keeping apple as any tested, and Milwaukee, which was at first considered a long keeping apple, but has been found not to keep much longer than McIntosh, which is really, up to the present, the best winter apple on the market for Eastern Ontario and Quebec as when grown there it keeps until March. Our list of winter apples at present recommended is, therefore, Milwaukee, Bethel and Scott Winter, with Pewaukee, American Golden Russet and Tolman for home orchards.

Another great need for the colder parts of Eastern Canada is summer and autumn apples of better quality, and this was taken into consideration when breeding new sorts. Why should the consumer of apples have to continue indefinitely to use Yellow Transparent, Oldenburg and Wealthy for dessert apples when there are such great possibilities of obtaining better sorts.

After the very severe test winter of 1903-04, it was found that still hardier parents must be used if we were to hope to obtain long keeping varieties hardy enough to stand these severe winters, hence the Russian apples were used more in breeding after that time. Trees from these crosses have shown superior hardiness, but most of the varieties are not good enough in quality.

With this brief preliminary account of the object in view, the following alphabetical list is given of varieties used as parents and from which trees have fruited:

American Golden Russet, Anis, Anisim, Antonovka, Baxter, Bethel, Dyer, Fameuse, Forest, Gano, La Victoire, Langford Beauty, Lawver, Lowland Raspberry, McIntosh, McMahan, Malinda, Milwaukee, Newton, Northwestern Greening, Northern Spy, Oldenburg, St. Lawrence, Salome, Scott Winter, Shiawassee, Stone, Swayzie, Walbridge, Walton, Wealthy, Winter Rose, Winter, St. Lawrence—33 varieties.

The following additional varieties have been used more recently, but, as the trees are just beginning to bear, or not yet in bearing, no comment is made on them:

Adonis, Barnack Beauty, Bingo, Bramley Seedling, Cellini, Charlamoff, Cobalt, Cox Orange, Crimson Beauty, Crusoe, Danville, Delicious, Dudley, Glenton, Gravenstein, Grimes Golden, Haas, Hibernal, Jewel, Lora, Monmouth, Martin, Nestor, Niobe, Piotosh, Printosh, Niedzwetzkyana, P. baccata, Redman, Red June, Rosalie, Rosilda, Rouleau, Tompkins King, Wagener, Wapella, Yellow Bellflower, Yellow Transparent—38 varieties.

This makes a total of 71 varieties and a very large number of combinations of these.

When the breeding work was begun in the horticultural division in 1895 there were as already stated only four or five late keeping apples hardy enough to be recommended for planting in the Ottawa District. As the result of breeding work at Ottawa, there are now at least 200 late keeping varieties which proved hardy enough to withstand the very severe winter of 1917-18. Of these 200, however, there are very few which we are yet prepared to recommend as another test winter is required to confirm that test. Moreover, the quality of a large proportion of these is not good enough to warrant their introduction.

One fact that has been impressed upon us more and more as the seedlings from various combinations have fruited, is that high quality, as measured from the dessert standpoint, must be a characteristic of both parents if high quality is to be obtained in many, if any, of the seedlings from a cross. With practically no hardy late keeping varieties of high dessert quality to use as one of the parents at Ottawa, the quality of most of the long keeping sorts has been disappointing.

Open pollinated Northern Spy has proved an exception. Seed was taken in 1898 from fruit of the Northern Spy top-grafted on Wealthy. The Wealthy was in full bloom on May 19 that year and Northern Spy on May 22, and no other variety as good in quality as Wealthy was near, so that there is a possibility that Wealthy was the male parent, though there is nothing to indicate this in the seedlings. Detailed descriptions of all the trees which fruited were made, there being 158 in number. Of these, the season of 40, or 25.3 per cent, was about the same as Northern Spy, namely, long keeping varieties, and 46, or 29.1 per cent, were good to very good in quality.

Take the Gano, on the other hand, which is no better than Ben Davis in quality. This was open pollinated, and certainly nothing poorer than it in quality pollinated it and, while out of 88, of which decriptions were made, 40, or 45.5 per cent, were long keeping apples somewhat of the season of Gano, 68, or 76.2, per cent were of the same quality as Gano, namely, only medium or below medium, and only one tree produced fruit of good quality.

There are two outstanding cases among the open pollinated long keeping varieties. Others were Lawver, Salome and American Golden Russet, and, from these, few varieties of really good quality have been obtained.

Some of the hand pollinated crosses where Northern Spy has been used as one of the parents of the cross have fruited. Of the cross, Northwestern Greening X Northern Spy, two only have been described. They were both late keeping varieties, and one was medium in quality and one above medium to good.

Of Northern Spy X Milwaukee, 10 have been described, of which 4 keep until February or later, and the remaining 6 to March or later. Two are good in quality, 6 above medium, and 2 medium in quality.

Many of the Northern Spy open pollinated seedlings have a distinct Spy-like flavor, but some, though the flavor is Spy-like, have a rather peculiar and not altogether pleasant flavor, resembling that of the Paw Paw apple. This flavor was also noticed in Northern Spy X Milwaukee.

Northern Spy is considered one of the best parents used, but, as it is not continuously hardy at Ottawa, another test winter is needed to find which of the seedlings are much hardier.

Undoubtedly the parent which is responsible for the largest proportion of promising seedlings is the McIntosh. This variety was first used in hand pollination in 1899, and has been used more or less, ever since.

The Lawver had proved the longest keeping variety which had fruited at the Experimental Farm, Ottawa. The fruit of this variety is of a solid red color, above medium in quality, and up to that time the tree had proved hardy at Ottawa. It was thought that the quality of the seedlings of a cross between this and the McIntosh, would be of at least good quality and would give the long looked for hardy long keeper. The first disappointment was after the winter of 1903-04, when a large proportion of the trees of this cross were found winter-killed, the Lawver itself

being killed that winter. If the McIntosh had not given seedlings of better quality than came from this cross it could not be claimed that it was a desirable parent, for, of 52 varieties, which have fruited, only 7 were of good quality, or 13.5 per cent. Reciprocal crosses were made between these varieties. Nineteen varieties of McIntosh X Lawver were described, 15 of which, or 79 per cent, were longer keeping than McIntosh. Only one when McIntosh was female, of 5.3 per cent, was good in quality.

Of Lawver X McIntosh, 23 have been described, 16 of which, or 69.6 per cent, were longer keeping than McIntosh. With Lawver as the female, 8, or 34.3 per cent, were of good quality.

It is interesting to note that of McIntosh X Lawver of the 19 which were described, 94.7 per cent had red predominating, or only one which had not and that was about 50 per cent red, and of the 23 Lawver X McIntosh, which were described, 87 per cent had red predominating, or only 2 which had not.

The fruit of most of the varieties is wonderfully symmetrical, resembling the McIntosh in this respect.

This cross is very interesting as showing that the high color of both parents was retained in nearly all of the F_1 generation; that a very large proportion were longer keeping than McIntosh and were of the season desired, and, doubtless, if a sufficient number of the seedlings had proved hardy there would have been enough of good quality to have considered this a satisfactory cross.

The best evidence of the great value of McIntosh as a parent is from the open pollinated seedlings of it. Seed was saved from a single tree of McIntosh in 1898. The male parent is not known, but Wealthy and an apple of good quality of the Fameuse group called Edgehill were two varieties within 30 feet of it and in bloom at the same time. There is no evidence, however, of the influence of either of these 2 in the seedlings.

Technical descriptions have been made of 141 varieties raised from open pollinated seed. Of these 70, or practically 50 per cent, were of good to very good quality. There were 103, or 73 per cent, that have red as the predominant color. There were 50 or 35.4 per cent, that were as long keeping as the McIntosh, and a few of which were a little better keepers than that variety, None of these longer keepers are considered as good as McIntosh. Of the remaining 64.6 per cent of summer, autumn, and early winter apples, there is a large number which are very promising and a few of which are now being introduced. These are Melba, Joyce, Pedro, Patricia and Lobo, all ready for use before McIntosh, all good to very good in quality, and all highly colored, it is believed that some of these varieties will before long be very popular summer and autumn sorts unless something better is originated. Few varieties of open pollinated McIntosh have so far proved too tender, most of them appearing to be as hardy as, or hardier than, McIntosh.

Shiawassee has proved a good parent so far as obtaining good quality is concerned where open pollinated seedlings have fruited. It has not been hand pollinated. It is of the Fameuse group.

Winter St. Lawrence, also apparently of the Fameuse group,

has given some early apples of good quality. Fameuse itself has proved a poor parent when open pollinated, but when crossed with Lawver has given some long keeping apples of good quality.

With regard to plums, it may be said that varieties of Prunus nigra have, because of the early ripening of the fruit and hardiness of the tree, proved very satisfactory, a local early variety called Carstesen having given, when open pollinated, some larger and better plums than the parent.

The only other fruit, of which mention shall be made here, is the strawberry, and it is merely to record that open pollinated seed of William Belt and Bubach gave a remarkably fine lot of seedlings, perhaps the best being the Portia a seedling of William Belt, Hermia, a William Belt seedling, and Cassandra, a Bubach seedling, are also very promising.

Apple Pollen and Pollination Studies in Maryland*

By E. C. Auchter, *University of Maryland, College Park, Md.*

DURING the past 15 years in Maryland, general observations have been made and recorded concerning the crossing of different varieties of apples and pears in connection with the fruit breeding investigations, a preliminary report of which was given by the writer (2) before this Society last year.

In the spring of 1919, however, special pollination studies were started by the Horticultural Department and have been in progress since that time. Although only three years results have been secured, they are presented at this time with the hope that the results may be of some value to other workers in the field, and that they may encourage new investigators in this work to eliminate in their studies as many variable factors as possible so that future pollination results in different sections of the country may be more comparable and authentic.

Self Sterility versus Self-Fertility†

Sterility tests made in 1919 and 1920 of 66 varieties of apples, showed that of this number 45 were self-sterile, 12 were self-fertile and 9 were partially self-fertile. In 1919, approxi-

*In this work the writer has had the assistance at different times of the following senior horticultural students: A. N. Pratt, B. L. Burnside, W. P. Hicks, D. P. Perry and Paul Walker, Acknowledgment is hereby made of their valuable assistance.

† In this paper the term "self-sterile" is used to designate the fact that blossoms will not set fruit when pollinated with their own pollen. "Self-fertile" is used to designate the fact that blossoms will set fruit when pollinated with their own pollen. Both Kraus (59) and Chittendon (16+17) have shown, however, that this usage is not technically correct.

mately 1000 blossoms of each variety were inclosed in manila sacks while the blossoms were in the pink stage and left until flowering was over. The sacks were then removed and a record made of the number of fruits set. This record was again made after the "June drop". In all cases an extra 1000 blossoms were counted on the trees outside of the bags to act as a check and to find the "normal set" in each case. In 1920, approximately 500 blossoms were used in the study of each variety. In the following table the percentage set and normal set are not given in this preliminary report. The results of certain other investigators are included and compared whenever they happened to test any of the varieties included in the Maryland list. The sterility of other varieties than those listed in the Maryland tests were often studied by other investigators, but their results are not included in this report. It was noted in our tests that the presence of aphids in a sack appeared to be correlated with a better set of fruit. Others have noted this same condition. The method by which aphids cause an increased set should be studied. It may be due to a better distribution of pollen, or to some other cause, which is not clear at this time. It will be noted later that brushing of the blossoms did not cause a better set, so aphids probably exert some other influence besides simply causing a better distribution of the pollen, as commonly held.

TABLE I

Lists of Self-Sterile and Self-Fertile Apple Varieties *

Variety	Maryland 1919	Maryland 1920	Delaware	Oregon	Washington	Idaho	Maine	England	England
Akin, ...		S							
American Beauty, ...		S							
Arkansas, ...	S	S	S	S		S			
Arkansas Black, ...	S	S		S		S			
Baldwin, ...		P-SF		F	F		F	F	
Beach		S							
Bloomfield	S	S							
Boiken		S							
Ben Adams	S								
Bismark	S								F
Bonum		P-SF							
Chicago	S								
Cox Orange		F				P-SF		S	F
Dickinson		P-SF							
Domine	S			S					
Early Ripe	S	S	S						
Early Harvest		F	P-SF			P-SF	S		
Gano	P-SF								
General Grant	S								
Grimes Golden	F		S	F	P-SF	P-SF		S	
Hewes Cider	S	S							
Heidemeyer		S							
Hogg		S							
Ingram		F							
Jonathan Buler		S							

Variety	Maryland 1919	Maryland 1920	Delaware	Oregon	Washington	Idaho	Maine	England	England
July		S							
Kinnaird	S	S							
Lawver	S	S			S				
Lowell		F							
Mann	S	P-SF		P-SF		P-SF			
Maiden Blush		F		S	S	F			
Martha	S	S							
Mammoth Grimes		F							
Major		S							
McIntosh		S			F	S	S		
Mother	F	F				P-SF			
Molasses	S								
Newtown Spitzenburg		S							
Oldenburg	S	S		F	F	F	F	F	F
Red Astrachan		P-SF	P-SF				S		F
Red June		S				F			
Red Pearmain		S							
Rome	F			S	P-SF	P-SF			
Shackleford		S							
Scarlet Pippin		S							
Shockley		S							
Smith Cider	S								
Summer Rambo		S							
Summer Pearmain		S							
Smokehouse	S	S							
Stark		S	S	P-SF					
Stayman Winesap	S	S	S			P-SF			
Stella	P-SF								
Tompkins King	F	F		S	S		S		F
Transcendant	S			S		S			
Vandivere		S							
Winesap	S		S	S	P-SF	S			
Wealthy	F	F		S	P-SF	P-SF		F	F
Winter Permain		S							
Winterstein		S							
Whitney Crab	P-SF								
Wolf River		S							
Yakor		S							
Yellow Siberian	S								
Yellow Transparent	F		F	P-SF	S	F			F
York Imperial	F	P-SF	P-SF	S					

S—Self-Sterile F—Self-Fertile P-SF—Partially Self-Fertile

A study of the above table shows that in Maryland a large percentage of the varieties are self-sterile and should not be planted in solid blocks when orchards are planted. It will be noted that not all of the varieties were tested in both years. Of the 15 varieties, however, which were tested in both years, 14 showed the same result in each year. The Mann, however, gave contrary results. When the results of other states are compared, it can be seen that the self-sterility, or self-fertility of a variety, may vary in different sections. The per cent of sterility or fertility may vary, however, in the different sections. and for this reason it is sometimes hard to accurately compare the amount of

sterility or fertility in different sections. We feel safer, however, in saying that such varieties as Arkansas Black and Arkansas are self-sterile in all sections, and that the Baldwin is self-fertile in all sections, when the results as listed are uniform in these sections. Differences in climatic conditions, the age of the tree, fertilizer, pruning and cultural treatments, and thus the vigor of the tree, no doubt, influence the apparent sterility of a variety in different years and in different sections. Kraus has stated that a variety might be self-sterile three years and self-fertile during the next two years. Waite (89) noted that self-sterility of a variety varies under different conditions and Morris (68), Wicks (95), and Gowen (43) have also recently drawn attention to this variability. The causes of self-sterility in different plants have been studied by Kraus (58), Dorsey (25 and 26), Moore (67), East (28 and 33), Compton (20), Stout (81), Correns (22), Knight (57) and many other investigators, but this question will not be discussed in this paper. Sterility studies with other fruits have been investigated by Gardner (40), Tufts (84 & 85), Hendrickson (51 & 52) Marshall (65), Beach (10), Palmer (72), Reimer (78), Detjen (24 & 78), Fletcher (38), Valleau (86), Sutton (83), Chittendon (16), Hooper (54) and many others.

Value of Bagging Method to Test for Self-Sterility

Questions have often been raised concerning the accurateness of the bagging method of testing sterility, when the bags were not removed during full bloom and the flowers brushed to insure self-pollination. Some investigators suggest that it is not enough to simply bag up the bloom and assure that self-pollination takes place without brushing. They suggest that if brushing were done, some of the varieties which otherwise appear self-sterile might then set fruit.

In order to check up this question, some studies were made in the spring of 1920. Certain varieties known to be self-fertile were included to see if brushing would increase the set of fruit in such cases over no brushing and some varieties shown to be self-sterile by the bagging method were included to see if brushing would change the results.

TABLE II.

Brushing versus No Brushing in Bagging Tests of Self-Sterility

VARIETY	Not Brushed			Brushed			Normal (check)		
	Number Blossoms Bagged	Number Set	Per Cent. Set	Number Blossoms Bagged	Number Set	Per cent. Set	Number Blossoms Counted	Number Set	Per cent. Set
Wealthy	1059	48	4.53	799	15	1.88	799	180	22.5
Grimes Golden	661	11	1.66	662	1	.15	487	107	21.9
Yellow Transparent ..	514	14	2.72	42	0	.0	309	82	26.8
Gano	1173	1	.09	607	3	.49	657	275	41.8
Stayman Winesap	845	0	.0	560	0	.0	904	48	5.31
Arkansas Black	1120	0	.0	228	0	.0	635	10	1.57
Arkansas	409	0	.0	543	0	.0	419	20	4.77
Lawver	1377	0	.0	257	0	.0	1000	74	7.4

A study of Table II shows that the act of removing the bag and brushing the pistils did not increase the set of fruit in the case of the four self-fertile varieties listed, nor did it cause a set of fruit in the self-sterile varieties. In fact, a slightly better set was secured when brushing was not done. It is questionable whether this fact is significant, however, and further tests may not show this advantage. Evidently pollen is distributed over the stigma whether the blossoms are brushed or not. It will be noted that the "normal set" is much higher than the "set" under the bags in the case of the self-fertile varieties. This may be due to the fact that the blossoms outside of the bags were pollinated with different varieties, or that conditions within the bags were somewhat abnormal, so that the percentage set was somewhat reduced. Similar results to the ones shown in the table were obtained with several other varieties not listed.

Thus, bagging is apparently a safe method of testing the self-sterility of apple varieties, even though the pistils are not brushed. Lewis came to similar conclusions in his study of this question. Alderman (1), Vincent (87) and Morris (68), have also shown that the bagging method is apparently as satisfactory a test of self-sterility as when the whole tree is inclosed in muslin tents.

From Table I it can be seen that many of our common varieties are self- sterile. In general, experiments have shown that even the self-fertile varieties are benefiitted by cross-pollination. In selecting varieties to act as pollinizers, it is, of course, essential that such varieties bloom at approximately the same time as the varieties to be pollinated. Blooming periods of many apple varieties overlap sufficiently to take care of cross pollination. Cer-

tain varieties, however, are very early bloomers while others bloom so late that no intercrossing would probably take place. In such cases, information concerning blooming data becomes important.

Blooming records have been secured on many different varieties for several years in Maryland. The exact blooming period will be influenced and will vary in different years under different climatic conditions. Age, vigor of tree, site of orchard, and many other factors may cause the blooming dates for any one variety to vary. Records taken over a number of years and averaged can generally be used as a safe index, however, in determining the blooming period. The varieties in Table III are arranged in order of the appearance of the first blooms. The period over which bloom continued on the tree is shown. It can be seen that such varieties as Rome Beauty and Ingram bloom rather late to be the most efficient pollenizers for such varieties as Oldenburg, Ben Davis, Arkansas, etc.

Intersterility and Mutual Affinity of Apple Varieties

It has generally been taken for granted by some of the earlier workers that any variety of apples would cause a suitable set of fruit if crossed on any other variety. In such cases it was probably noted that a certain variety set fruit when pollinated with pollen from some other variety, but often failed to set fruit with its own pollen. Without making very many different crosses to see if this condition always existed, it was probably assumed that there was practically no intersterility among apple varieties or that its occurence was rare. Quite recently Sutton (83) after a study of several apple varieties in England, has stated, "Provided that a variety produces plenty of pollen and flowers simultaneously with the variety which it is intended to pollinate, any variety, at least of plums and apples, will probably serve for this purpose, apart from the special case of the Coe varieties of plums and their presumable co-derivative, Jefferson". Barker and Spinks (7), of England also state "No definite cases of incompatability of crossing between any varieties have been observed, nor has it been found that any varieties are distinctly good or bad for pollinating certain other varieties".

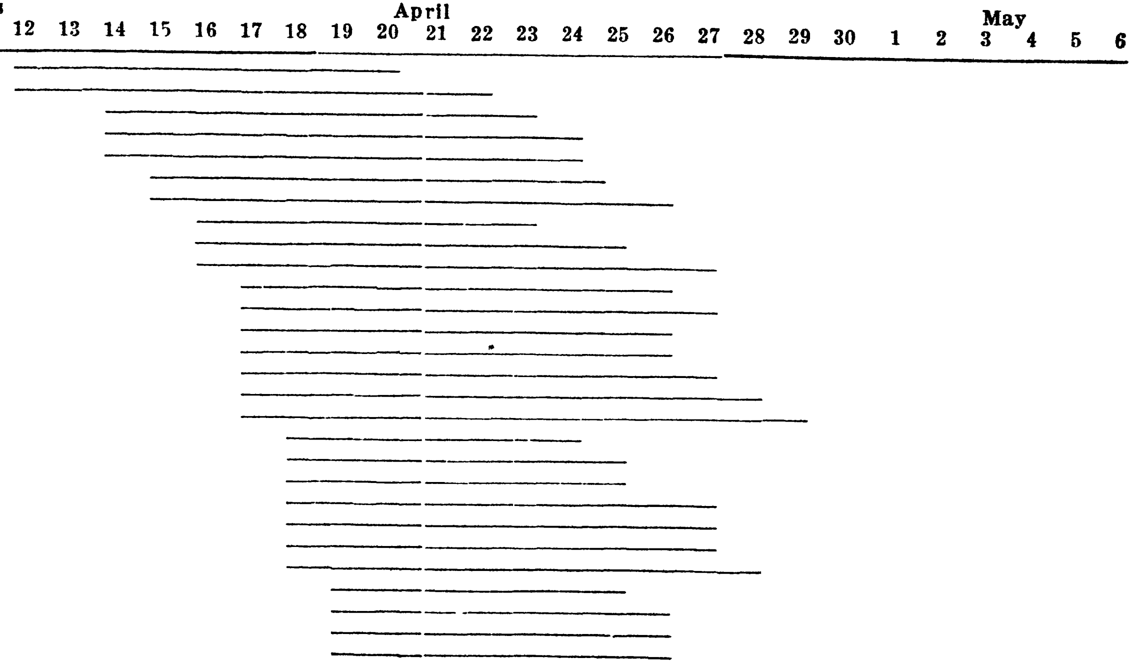
Recently, since a large number of different varieties have been intercrossed by different investigators and their results have been made available, this question has assumed more importance. Thus, Vincent (87), Morris (68), Gowen (43), Ballard (6a), Wicks (95), Palmer (71) and others have noted where certain crosses persistently gave a poor set of fruit. In some cases, the cross made in one direction was apparently satisfactory, while the reciprocal cross produced negative results. In other cases certain varieties appeared to be intersterile or imcompatible, regardless of which way the cross was made.

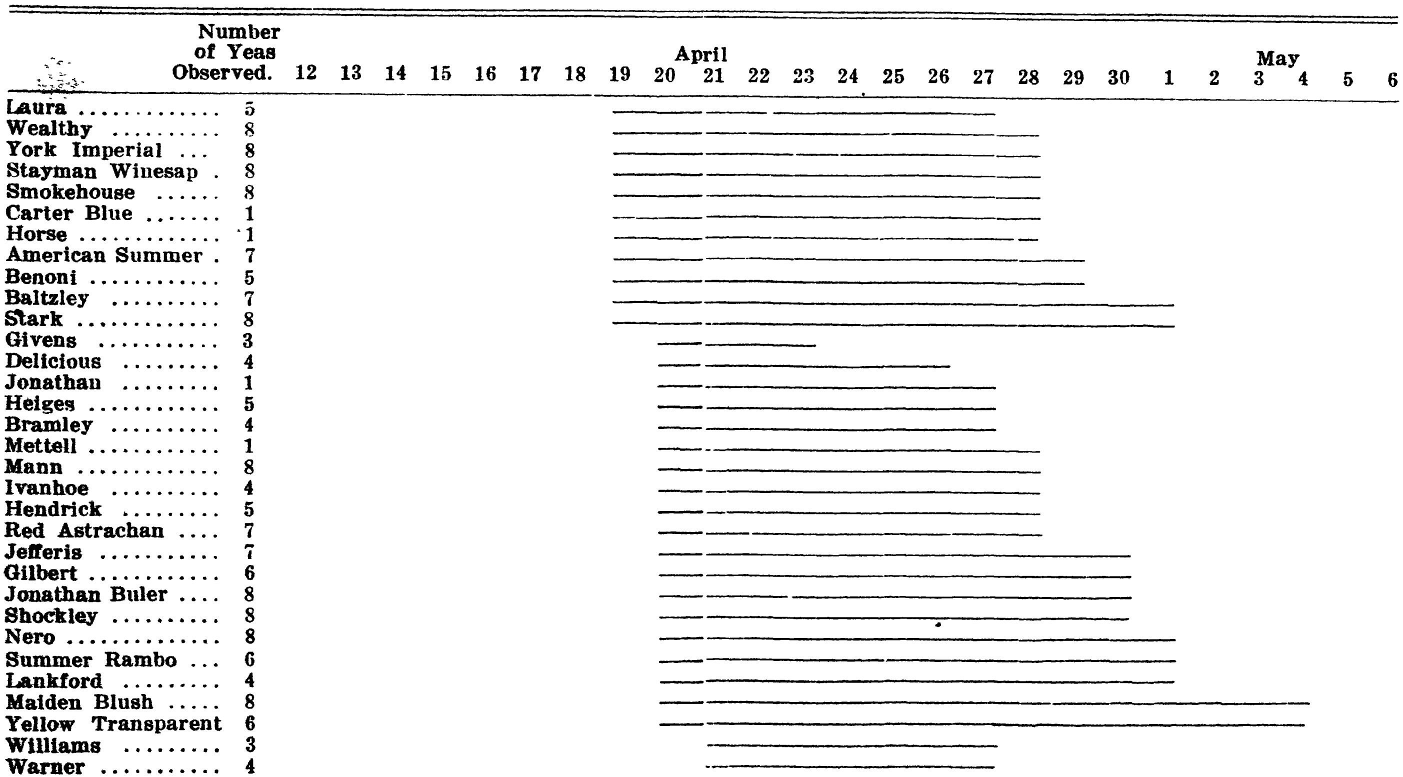
Some studies, which were made in 1919 and 1920 at the Maryland Station, are presented, more with the idea of adding addi-

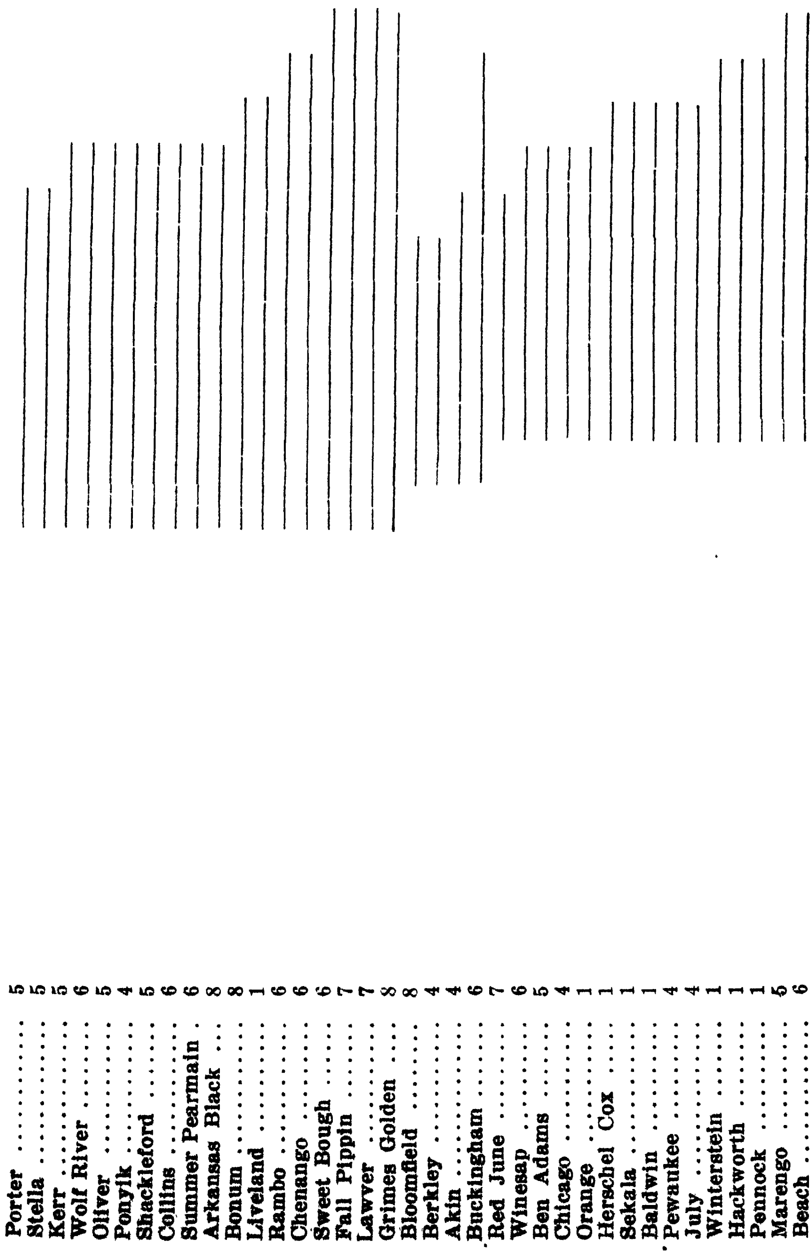
TABLE III.

Average Blooming Period of Apple Varieties

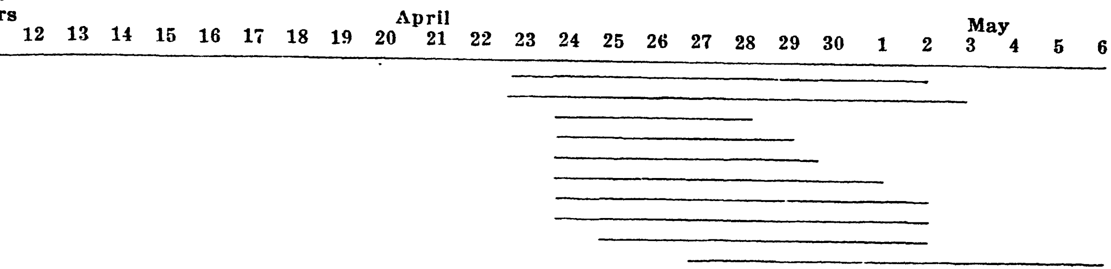
Variety	Number of Years Observed.
Yellow Siberian	4
Bledsoe	3
Molasses	6
Early Colton	5
General Grant	5
Oldenburg	5
Ben Davis	4
Montreal	3
Transcendent	5
Early Harvest	7
Martha	6
Arkansas	4
Whitney	6
Domine	7
Gano	5
Early Ripe	8
Bismarck	6
Yakor	1
Henry Clay	1
Major	8
Smith Cider	7
Hewes Cider	1
Gravenstein	8
Mills	5
Pine Stump	4
Fallawater	7
Alaska	6
Shannon	4




Number of Yeas Observed.
April
May
12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 1 2 3 4 5 6
Laura 5
Wealthy 8
York Imperial ... 8
Stayman Winesap . 8
Smokehouse 8
Carter Blue 1
Horse 1
American Summer . 7
Benoni 5
Baltzley 7
Stark 8
Givens 3
Delicious 4
Jonathan 1
Helges 5
Bramley 4
Mettell 1
Mann 8
Ivanhoe 4
Hendrick 5
Red Astrachan 7
Jefferis 7
Gilbert 6
Jonathan Buler 8
Shockley 8
Nero 8
Summer Rambo ... 6
Lankford 4
Maiden Blush 8
Yellow Transparent 6
Williams 3
Warner 4


Porter 5
Stella 5
Kerr 5
Wolf River 6
Oliver 5
Ponyik 4
Shackleford 5
Collins 6
Summer Pearmain 6
Arkansas Black 8
Bonum 8
Liveland 1
Rambo 6
Chenango 6
Sweet Bough 6
Fall Pippin 7
Lawver 7
Grimes Golden 8
Bloomfield 8
Berkley 4
Akin 4
Buckingham 6
Red June 7
Winesap 6
Ben Adams 5
Chicago 4
Orange 1
Herschel Cox 1
Sekala 1
Baldwin 1
Pewaukee 4
July 4
Winterstein 1
Hackworth 1
Pennock 1
Marengo 5
Beach 6

	Number of Years Observed.
Kinnaird	7
Bailey Sweet	6
Gillispie	3
Dickinson	4
Quarter	4
Salome	1
Mother	7
Rome	5
Magyar	1
Ingram	3



tional evidence on this question,than in attempting to decide any phase of it.

Intersterility Studies in Maryland

Since the Stayman Winesap variety is probably the leading apple variety in Maryland, it was primarily used as a male and female parent in intercrossing the more importanat varieties in Maryland. Table IV gives the results in 1919 and 1920.

TABLE IV

Intersterility Tests

Variety Crosses	1919 Number blossoms crossed	1919 Number set	1920 Number blossoms crossed	1920 Number set
Grimes Golden x Stayman Winesap	548	2		
York Imperial x Stayman Winesap	516	0	100	0
Rome Beauty x Stayman Winesap	483	0		
Arkansas x Stayman Winesap	409	0	81	0
Winesap x Stayman Winesap	341	0		
Tompkins King x Stayman Winesap	258	0		
Kinnaird x Stayman Winesap			194	0
Arkansas Black x Stayman Winesap			51	0
Stayman Winesap x Winesap	137	0	236	0
Stayman Winesap x Arkansas	352	0	223	0
Stayman Winesap x Arkansas Black			283	2
Stayman Winesap x Kinnaird			202	1
Stayman Winesap x Grimes Golden	558	16	231	0
Stayman Winesap x Rome Beauty	539	56	239	0
Stayman Winesap x York Imperial	472	15	246	1
Grimes Golden—Open Pollinated	1008	110	487	107
York Imperial—Open Pollinated	1000	145	808	118
Rome Beauty—Open Pollinated	68	4	58	19
Arkansas—Open Pollinated	1140	28	419	20
Kinnaird—Open Pollinated	860	236	528	41
Arkansas Black—Open Pollinated	1055	142	110	3
Winesap—Open Pollinated	1000	128		
Stayman Winesap—Open Pollinated	1000	100	1190	48
Tompkins King—Open Pollinated	1020	52	126	3

One of the most noticeable things in Table IV is the lack of any resultant fruit except in the case of Grimes Golden when Stayman Winesap is used as the male parent. These results check up with those of Ballard (6a) where it is shown that in all of his crosses, Stayman Winesap caused a set of fruit only with Grimes Golden and Early Ripe. Close (18) in Delaware noted the results were poor when Stayman Winesap was used as a male parent.

Considering the results of 1919 when Stayman Winesap is used as the female parent, one might conclude that the varieties within the Winesap group were intersterile. Grimes Golden, Rome Beauty or York Imperial give a set of fruit when crossed on Stayman Winesap, but no fruit is produced when Winesap or Arkansas are used as male parents. Although these same crosses

produced no fruit during the next year either, still pollen of the Arkansas Black and Kinnaird, probably members of the Winesap group, did cause a set in 1920 although Grimes Golden and Rome Beauty did not. Thus, we would not be safe in saying that all the varieties within the Winesap group were intersterile. It does appear, however, that the crosses, Stayman Winesap by Winesap and Stayman Winesap by Arkansas, are sterile as well as the reciprocal cross. Our studies have shown that Winesap and Arkansas are apparently intersterile also. Powell (75) and Close (18) obtained similar results in their study with these varieties and Gowen (43), when he compared the results of different investigators, drew attention to the same fact. During the years 1915, 1917 and 1918, Palmer (71) in Canada secured only one doubtful fruit from 1392 hand pollinated blossoms of Rhode Island Greening X McIntosh.

In our work, pollen from all varieties was collected at the same time, kept under the same conditions, and applied during the same morning on one tree which was used as the female parent. We believe that this is a necessary precaution, as will be brought out later. It might be well in the future to cross all of the same varieties on individual trees of different ages and growing under different enviromental conditions, in order to see how the set of fruit would be influenced under these different conditions.

Some studies with early apples in 1919 gave the following results.

TABLE V

Early Apple Crosses

Variety Cross	Number blossoms crossed	Number set
Early Ripe x Red Astrachan	245	21
Early Ripe x Red June	253	25
Early Ripe x Oldenburg	171	0
Early Ripe x Bloomfield	258	0
Early Ripe x Early Ripe	700	0
Early Ripe normal set	515	92
Red June x Red Astrachan	295	7
Red June x Early Ripe	1031	50
Red June normal set	475	59
Red Astrachan x Red June	209	9
Red Astrachan x Early Ripe	239	20
Red Astrachan normal set	144	42

It can be seen that in general the early varieties worked with were cross-fertile. Pollen of Oldenburg and Bloomfield did not cause any fruit to set, however, when applied on Early Ripe stigmas. Red Astrachan and Red June pollen caused a good set of fruit. The pollen of all four varieties was collected in the same way and applied at approximately the same time on uniform spur clusters of the same Early Ripe tree. All trees were middle-aged and bore a medium sized crop of fruit. One

year's results are, of course, only suggestive and the tests should be repeated before any definite conclusions should be drawn. The fact, however, that all crosses were made on uniform spurs of the same tree, under the same conditions, adds more value to one year's results.

1920 Lawver Crosses.

In 1920, a healthy Lawver tree 20 years old bearing a fair set of bloom, was selected as a female parent, and 19 different varieties were crossed on this one tree. Pollen from 9 varieties was collected on April 25th and applied by the same person on the morning of April 26. Pollen from the other 10 varieties was collected on April 26 and applied on the morning of April 28. In both cases, emasculation was performed just before the pollen was applied. Results are shown in Table VI.

TABLE VI.

Set of Fruit on One Lawver Tree From the Application of Pollen Taken From Nineteen Varieties.

Variety Cross	Date of pollination	Number blossoms crossed	Number set
Lawver x Arkansas Black	4-26	164	1
Lawver x Grimes Golden	4-26	123	0
Lawver x Oldenburg	4-26	101	0
Lawver x Kinnaird	4-26	92	3
Lawver x Stayman Winesap	4-26	85	0
Lawver x Arkansas	4-26	52	0
Lawver x York Imperial	4-26	55	0
Lawver x Rome Beauty	4-26	211	0
Lawver x Early Ripe	4-26	127	0
Lawver x McIntosh	4-28	201	0
Lawver x Stark	4-28	211	0
Lawver x Nero	4-28	183	0
Lawver x Domine	4-28	32	0
Lawver x Bloomfield	4-28	373	4
Lawver x Baldwin	4-28	185	0
Lawver x Major	4-28	209	0
Lawver x Smokehouse	4-28	171	0
Lawver x Wealthy	4-28	186	11
Lawver x Mann	4-28	200	7
Lawver x Lawver	4-28	545	0
Lawver—normal set	4-28	485	36

These results suggest that cross-sterility may be more serious than we have thought in the past. Certainly they show that a more careful study of this whole problem might well be made. It appears very probable that something more than simultaneous blooming dates and amount of pollen produced, should be considered when selecting pollenizers to plant in an orchard.

Apparently pollen from only five out of the 19 varieties studied

was capable of causing a set of fruit with Lawver in the Station orchard in 1920.

It is interesting to note in this connection that Hooper (54) of England states that when he tried the polen of 10 different varieties of apples on the same Cox Orange tree, only two of them, High Canons and Bramleys, gave a set of fruit. In addition he found that only one variety was self-fertile out of 67 varieties that were bagged and tested.

Corrier (21), on the other hand, finds that under his conditions the Cox Orange develops good crops when crossed with Stirling Castle, Beauty of Bath and Duchess Favorite, but gives no fruit when crossed with Bramley Seedling. He states, "Even with varieties which are potent and do produce seed, there appears still to be a variation in their affinity."

Pollen Germination Tests

Booth (12) has shown that the pollen gains of self-sterile varieties of grapes were irregular in shape and would not germinate when placed in suitable media. To see if there was any such correlation in the case of the apple, germination tests in the spring of 1921 were made with the pollen of 15 varieties. No decided differences in the shape of pollen were noticeable. Pollen grains of those varieties studied apparently lost water when exposed to the air, and appeared to shrink, leaving them rather oblong in appearance. When placed in a germination media, water was absorbed and practically all grains became turgid, globular and regular. Martin and Yocum (64) also noticed this condition in the pollen of the varieties which they studied. In order to find the best germinating media, various concentrations of fructose and cane sugar solutions were used. In our tests, better results were secured with cane sugar than with fructose. Solutions of 2, 5, 10 and 15 per cent of cane sugar and 3 and 5 per cents of fructose were studied. The 10 per cent solution of cane sugar appeared to give slightly the best results although good germination was secured in the 2.5 and 5 per cent solutions. Knight (57) obtained best results with an 8 to 10 per cent cane sugar solution, while Dr. Eckerson (57) found a 3 per cent fructose solution to be preferable. Martin and Yocum (64), Sandsten (80) and Adams(1a) obtained best results with 2.5, 3, and 5 per cent cane sugar solutions respectively. This variation in results is of little importance, however, as several factors might enter to cause the difference; the sugars used might not be equally pure; the method of making up the solutions might not be comparable, and Martin and Yocum (64) have shown that if more concentrated solutions or lower temperatures are used, a longer period of time must be allowed for germination before observations are made. It is worthy of note that both Knight (47) and Martin and Yocum (64) found that apple pollen germinated fairly well in distilled water. The last mentioned investigators found that pollen germinated as well, if not better, on moist animal membranes as in a 2.5 per cent sugar solution. From these studies they state, "The fact that the pollen germinated to a considerable extent in distilled water suggested that the sugar solutions functioned

in the germination of the pollen only in controlling the water supply," and again, "The longest tubes obtained in any of the sugar solutions and on the membranes were about two millimeters. This limit in growth was attributed to the exhaustion of stored food in the pollen grain, and since no more growth was made in the sugar solution than on the membrane, it was again evident that the pollen tubes did not use the sugar as food. It is evident from the behavior of the pollen in water, in the sugar solutions and on moist membranes, that germination depends only on the water supply." Knight (57) found, however, that he was able to secure lengths of ten millimeters in artificial media and that plugs cut off the contents of the tube from the rest of the grain when they were one millimeter in length.

In making up our sugar solutions, the number of grams, corresponding to the desired percentage of sugar, were dissolved in distilled water and enough water added to make a total of 100 cubic centimeters. It would have been well to have determined the exact percentage of sugar in solution by some method based upon the reduction of Fehlings solution.

The following table shows the results secured with a few varieties in 1921.

TABLE VII.

Percentage of Germination in Cane Sugar Solutions of Different Concentrations.

Pollen Variety	Time Hours	Temp. Fahr.	Per Cent of Germination. 2 per cent sugar solution	5 per cent sugar solution	10 per cent sugar solution	15 per cent sugar solution
Grimes Golden	22	70°	60	80	65	5
Grimes Golden	6	85°	70	75	80	60
Domine	6.5	85°	—	80	100	—
Oldenburg	2	85°	—	25	40	—
Mann	6.5	85°	—	60	100	—
Mother	6.5	85°	—	60	80	—
Smith Cider	6	85°	—	60	100	—
Stayman Winesap	6	85°	—	0	0	—
Stayman Winesap	22	70°	—	0	1	—
Arkansas	6	85°	—	0	1	—

It can be seen that the percentage of germination was slightly higher on the average in the 10 per cent solution. As a whole, the pollen of most of the varieties germinated equally well, whether the variety is listed as self-fertile or self-sterile in Table I. Thus, a similar correlation concerning sterility and pollen impotency as found in the grape does not appear to exist in apples. It is interesting to note that pollen of the Staymen Winesap and Arkansas gave practically no germination. It will be recalled that a very poor set of fruit resulted when the Stayman Winesap pollen was used on other varieties and that the Arkansas has uniformly been

reported as self-sterile by all investigators (Table I). The germination tests of the pollen of these two varieties must, of course, be repeated before much significance, or weight, can be given to the results. It is possible that good germination of the pollen may result under different conditions.

Some Factors Influencing the Accuracy of Pollination Results

Methods used by different investigators in studies on cross-pollination vary considerably. As a whole, most investigators have relied on large numbers and averages to offset such variable factors as maturity of pollen, maturity of pistils, age of pollen, length of time elapsing betwen emasculation and pollen application, temperature, rainfall, spur vigor as influencing set, (Heinicke) (47), age of tree, and health of individual trees used. It is possible that large numbers and averages will, to a degree, offset many of these factors, but at the same time, it is also possible that the large amount of contradictory evidence presented by different investigators, or between the results obtained in the same or different years by the same investigator, may be due to ignoring certain of these factors, especiallly when large numbers are not used.

Pollen From Small versus Large Blossom Buds

In cross pollination studies, pollen is collected and applied in many different ways. Thus some investigators bag up branches before the blossoms are open and later open the bags and collect the pollen in vials or in some cases, remove the blossoms and use these to actually brush on the stigmas. Others bring twigs into the greenhouse, place them in water, force the blossoms and then collect pollen. Some workers collect the unopened blossom buds, bring them into the office or greenhouse, remove the anthers and ripen them in petri dishes as shown in illustrations by Ballard (6a). No great care has been used in the selection of the buds other than the requirement that they must not have opened before the collection was made. This pollen is then applied by the finger or with brushes to the emasulated bloom at the proper time. Other methods are probably used also.

At Maryland, the method described last has been found very convenient and has been used. When this method was employed it seemed to the writer, that if small buds were selected instead of large buds about ready to open, the vigor and viability of the resulting pollen might vary. In one case, the pollen grains might develop and mature more normally as a result of remaining on the tree for two or three days longer. Tests were made in 1920 and 1921 to cover this question. Buds just showing pink and buds just about ready to open were selected at the same time and ripened under the same conditions. When the pollen was apparently ripe in both cases, it was applied *at the same time on the same branches of the same tree, on emasculated buds on spurs which had been selected because of their apparent uniformity*

of vigor and growth. Blossoms in the same stage of development (about ready to open) were selected for emasculation. In 1920, the male parent used was Grimes Golden and the female was Stayman Winesap. In 1921, Grimes Golden pollen was appled to York Imperial pistils. The Stayman Winesap and York Imperial trees were approximately 20 years old, were growing under cultivated and cover crop conditions, and were good, healthy trees. Each bore a medium sized crop of fruit in the year that the work was performed. The actual percentage results might have been different if younger and more vigorous trees had been used, but comparable results in the different groups would probably have remained approximately the same. Emasculation was performed just prior to pollen application in both years. Results are shown in Table VIII.

TABLE VIII.

Influence of Sources of Pollen on Set of Fruit. (Pistils Uniform and Normal Size).

	1920					1921				
Pollen source	Temperature	Weather	Number blossoms crossed	Number set	Per cent of final set	Temperature	Weather	Number blossoms crossed	Number set	Per cent final set
Small buds	76	Clear	90	3	3.03	62	Cloudy	90	0	0
Large buds	76	Clear	90	5	5.55	62	Cloudy	86	5	5.81

It can be seen that the set of fruit varied from nearly twice to five times as much when pollen from large buds was selected. Pollen from the small buds did not germinate as soon nor did as high a percentage germinate in some limited germination tests that were made in sugar solutions. Regarding the comparison of pollen taken from large buds and ripened with that which ripens normally on the tree, Martin and Yocum (64) state, "The sesults show that pollen taken from flowers just previous to their opening, or about the time the flowers are emasculated in experiments, is about as good as pollen from anthers which are dehiscing".

SET OF FRUIT ON SMALL VERSUS LARGE BLOSSOM BUDS

Many investigators apply pollen to the pistils as soon as they are emasculated. In such cases, most of the buds are emasculated and crossed regardless of size. It seemed important to find whether the pistils of small buds developed after emasculation, pollination and bagging and gave as good a set of fruit as normal pistils on buds just ready to break, when the pollen was applied at the same time in both cases.

Accordingly normal pollen from large buds was collected, ripened uniformly and applied at the same time to a number of

freshly emasculated small buds and a similar number of medium and large buds. The same trees and the same precautions were used as in the preceding test. Table IX gives the results.

TABLE IX.

Influence of Size and Development of Pistil

Size of Pistil (Buds)	1920 Temperature	Weather	Number blossoms crossed	Number set	Per cent final set	1921 Temperature	Weather	Number blossoms crossed	Number set	Per cent final set
Small	76	clear	91	1	1.09	59	cloudy	88	5	5.68
Medium ..	76	clear	116	3	2.59	59	cloudy	98	13	13.26
Large	76	clear	90	5	5.55	59	cloudy	87	9	10.34

It can be seen that the set of fruit varied considerably when pollen was applied to large pistils as compared to small pistils. Weather conditions might be expected to influence these results. If the weather was warm, the blossoms would develop rapidly and thus hasten the normal development of the pistils. In cool weather, the blossoms would not develop so quickly and thus the pistils in the small buds would be slower in developing. It can be seen, however, that the difference in results between small buds and large buds are quite uniform in both years, although in 1920 the weather was bright and warm, while in 1921 it was cool and cloudy. It will be noted that in 1921 the medium buds gave a little better set than the large buds, but approximately two and one-half times more than the small buds. The difference in the actual amount of set in the two years between different groups might be caused by several factors such as weather conditions, tree vigor, different varieties used, etc. Regarding the size of bud to use in crossing, Macoun (62) states, "The more the flower bud is developed the greater chances there will be that artificial pollination will be successful".

IMMEDIATE VERSUS DELAYED POLLINATION

It has been seen that it is hardly advisable to apply pollen on very small pistils immediately after emasculation. When the buds were large and ready to open, however, immediate pollination gave good results. Recommendations concerning the best time to pollinate after large buds are emasculated, have varied a great deal among investigators. Thus, some workers say that pollination should be done immediately, while others claim that one, two, or three days should elapse between emasculation and pollination, depending generally on weather conditions. In such cases, some workers say it is necessary to wait until the stigmas are receptive. Others say that the time should be deferred until the stigmas glisten with a stigmatic secretion. This secretion is as-

sumed to be necessary for pollen germination. However, Martin and Yocum (64) have recently stated, "On bright, warm days, we found no evidence of any secretion on the surface of the stigmas in the five varieties of apples investigated. The pollen germinated when lodged between the papillae in the absence of any secretion. The observations on the five varieties studied, showed that the germination of the pollen does not depend upon stigmatic secretions which exclude from the stigma, but upon the ability of the pollen to draw liquids from the papillae and it is obvious from the nature of the pollen that water is the only liquid necessary to start germination. Pollen lodged between the papillae was able to absorb from the papillae the required amount of water for germination", and again, "On bright days the stigmas were more glistening than on cloudy days, due to the greater reflection and refaction of light by the papillae, which to the unaided eye, resembles small drops of liquid". Middlebrooke (66) found that the cause of bad setting in certain varieties of grapes was due to the presence of a little drop of nectar hanging on the end of the pistil, which prevented the pollen from doing its work. He states, "The obstacle being removed, there was no difficulty in securing a thickly set bunch of berries".

Studies to determine the effect of immediate pollination versus delayed pollination were made in Maryland during 1920 and 1921. In all cases, several hundred blossoms were emasculated on the same day on uniform spurs, on similar branches of the same tree. Some were pollinated immediately and others at intervals of one, two, three, four and five days. *Fresh pollen was ripened each day from similar buds taken from the same tree, so that the pollen used would be as uniform as possible.* The results are shown in Table X.

TABLE X.

Effect of Immediate versus Delayed Pollination

Time of pollination.	1920. Temperature	Weather	Number blossoms crossed	Number set	Per cent set	1921. Temperature	Weather	Number blossoms crossed	Number set	Per cent set
Immediately ..	76	clear	104	32	30.76	60	cloudy rainy	87	9	10.34
One day .. later	76	clear	99	15	16.16	43	clear windy	64	5	7.81
Two days . later.	75	clear	87	7	6.8	48	clear	75	9	12.00
Three days later.	55	cloudy rainy	50	0	0	59	clear	42	2	4.76
Four days later.	55	cloudy rainy	104	1	.96	68	clear	35	2	5.76
Five days later.	77	clear	101	4	3.96	—	—	—	—	—

The results suggest that in warm, clear seasons like that of 1920, better results are secured from immediate pollination. In such cases a much higher per cent of set will be secured than if pollination is deferred. Booth (13) reported similar results in his studies. Evidently pistils develop rapidly and the egg cells degenerate quickly in warm seasons. Apparently apple stigmas in warm seasons are receptive as soon as the blossoms open, or shortly thereafter. Pollen applied at this time will remain on the stigmas and be ready to germinate as soon as conditions are favorable. Note that the cold and rainy weather on the third and fourth days in 1920 evidently reduced the set. When it became warm and clear again on the fifth day the set was increased again. It is, of course, possible that the set of fruit is decreased in the later cases, due to decreased food and water supply as a result of having the leaves inclosed in a sack and cut off from the direct rays of the sun.

In cold seasons like 1921 when the flowers remain inactive for periods of a week, there is apparently little correlation between the set and the time of pollination. Provided the pollen remains on the stigma and the pistil and egg cell development is checked by cold weather, but not injured, good sets of fruit will probably result from delayed cross-pollinations, if warm weather is not delayed too long after the crossing is done. In cool seasons, the percentage of set appears to be higher on those days which are a little warmer than the average, or when the temperature is warm for several hours following cross-pollination. Goff (42) and others have shown that pollen tube growth is checked by temperatures between 40° and 51° F. in the case of the plum. Knight (57) also noted that the rate of pollen tube growth in the apple is retarded in cooler weather. Martin and Yocum (64) found that apple pollen germinated much slower at low temperatures.

Many of the earlier investigators have reported concerning the influence of weather on the setting of fruit and more recently, Hedrick (48), Dorsey (27), Martin and Yocum (64), Middlebrooke (66) and Auchter (2) have published the results of their studies concerning certain weather conditions as affecting fruitfulness.

Influence of Age of Pollen on Set of Fruit

In connection with the studies on delaying the time of pollen application after emasculation, it was thought wise to investigate the set of fruit when pollen of different ages was used. Accordingly in 1921, Grimes Golden pollen was collected, ripened and used daily for five days on the same York Imperial tree. During this time the pollen was kept dry and at a temperature of 65° F. Certain normal blossoms on uniform spurs on the same branches were emasculated at daily intervals and pollen applied. Results are given in the following table.

TABLE XI.

Influence of Age of Pollen on Set of Fruit.

Age of pollen	Temperature	Weather	Number blossoms bagged	Number Set	Per cent final Set
One day	57	clear	81	5	5.88
Two days	43	windy & cloudy	101	3	2.97
Three days	60	clear	227	12	5.30
Four days	59	clear	142	5	3.52
Five days	68	clear	153	4	2.61

There was apparently very little difference in the value of the pollen as far as causing a set of fruit was concerned. Pollen properly kept will not deteriorate for at least a week during pollination work. Barker and Spinks (7) of England found similar results. Fletcher (37), Lewis and Vincent (61), Sandsten (80), Adams (1a), Crandall (23), Martin and Yocum (64) and others have shown that pollen can be kept for long periods and remain viable if kept in a dry condition at proper temperatures. Macoun (62), also states, "Pollen may be kept in good condition for several weeks if in a dry condition in closed bottles in a dark place".

FROZEN POLLEN

In 1921, after two cold nights of 20° F. and 22° F. when certain apple trees were in full bloom, pollen was collected, ripened and tested for germination. Although germinating a little slower than normal pollen, still a good percentage did germinate. The pistils, however, had been killed on this tree. Manaresi (63) found similar results in a germination test of peach pollen which had been subjected to frosts under orchard conditions. As a usual thing pistils are killed by moderately low temperatures, while the stamens remained green and apparently uninjured. In one Grimes Golden orchard of the state, however, an interesting exception was found to this general rule. In this orchard, after a cold snap, the pistils were apparently uninjured, while the stamens were dark and shriveled. This orchard also set a fair crop of fruit. Other varieties were nearby to supply pollen.

Sandsten (80) found that he could expose pollen to a temperature of -15° for less than an hour with no injury. Chandler (14) and Schaffnit (80a) exposed dry apple pollen to temperatures of -18° C. and -17° C. respectively for a long period with no apparent injury. Chandler (14) exposed some pollen which he considered not dry to -8° C. and found no injury. Manaresi (63) found germination of peach pollen was reduced one-half, when subjected to a temperature of -2.5° C. and that similar pollen subjected to a temperature of -8° C. germinated very little in maltose solution. Martin and Yocum (64) state, "Pollen kept frozen

up solid in water and sugar solutions for three or four hours gave a normal percentage of germination when its germination capacity was tested, thus showing no bad effects from cold".

Influence of Time of Day on Set of Fruit

Attention has been drawn by certain investigators to differences in pollination results when the work was done at different times of the day. It would appear, however, that only small differences or none at all, should occur, if the weather conditions were uniform throughout the day, and if the pistils were healthy in all cases. It is, of course, probable that different results would be secured if there were a different and decided change in the weather between night and morning. Grimes Golden pollen was used in 1920 on Stayman Winesap and Grimes Golden on York Imperial in 1921. The same tree and the same collection of pollen were used during the day. Results on this work are given below.

Table XII.

Influence of Time of Day on Set of Fruit.

	April 24, 1920.					April 7, 1921.				
Time.	Temperature	Weather	Number blossoms crossed	Blossoms Set	Per cent final Set	Temperature Fahr.	Weather	Number blossoms crossed	Blossoms set	Per cent final set
6:30 A. M.	70	clear	100	15	15.00	—	——	—	—	——
12:00 M.	85	clear	90	5	5.55	59	clear	87	9	10.34
7:30 P. M.	72	clear	89	4	4.5	58	clear	81	8	9.87

In both years, the results secured from noon and night pollination were approximately the same. The morning test in 1920 appeared to give better results, but this point should be repeated before drawing definite conclusions.

Application of Some of the Factors Influencing Pollination Results

A study of some of the tables presented emphasizes the need of using more care in our pollination methods and in the interpretation of re sults. In a study of the comparative value of several different varieties as pollinizers for some certain variety, the crossing should be done at approximately the same time on the same tree, if possible, and on freshly emasculated blossoms. (Table VI). When several blossoms are emasculated on the same day, and then certain numbers of them happen to be crossed with different varieties during the next two or three days, little weight can be given to the results as a measure of the comparative value of the varieties as pollinizers. It can be seen that the same variety would probably vary in different days, as much as would

the different varieties. Then too, it can be seen (Table X) that weather conditions might influence the comparative results in different days as much or more than the different pollenizers. In fact, some crosses might not set any fruit in certain years, due to weather conditions and if these were compared with results of other crosses, performed in more suitable years, the results would certainly be misleading. Certain trees of a variety might be in such a condition of health that practically no blossoms would set in a certain year. In such cases, no value could be given to any pollination results secured from such a tree. A check on the "normal set" of all trees should be kept as a safeguard against the occurrence of such a wrong interpretation of results. This is especially important in "mutual affinity" studies. The percentage set of blossoms on different varieties caused by the same pollenizer, should not be directly compared, but these percentages should be compared to the "normal set" of each variety. Since the "normal set" of each variety may vary considerablly, only in this way can the value of a pollenizer for different varieties be compared. In this connection, the "normal set" should by all means be recorded when testing a variety for self-sterility. One variety with fewer blossoms set (of the standard number studied) might be much more self-fertile than an adjoining variety with a much larger number. A knowledge of the basis upon which different investigators base their decision on the difference between self-fertility and partial self-fertility, or whether a variety is self-fertile or not, would aid when different results were studied and compared.

Among investigators, who collect, ripen and apply pollen by the same method as used in Maryland, care should be taken to secure pollen from large normal buds if any comparison of results are to be made. If pollen of two varieties was secured for pollinating and comparing the resultant set on the same variety, the source of pollen might influence the results more than the fact that pollen of two different varieties was used (Table VIII). In actual practice, pollen from one variety, say Ben Davis, might be collected on the same day as pollen from Rome Beauty in order to have both ready for certain tests the next day. In such a case, the chances are that most of the Ben Davis buds, from which anthers were collected, would be normal, large buds, while the Rome Beauty buds would probably be very small. It is possible then that any comparative results might be influenced more by the source of pollen than by the different varieties. In this way results of the same crosses might vary in different years or in different parts of the same state in the same years, regardless of weather, or differences of tree vigor.

What has been said regarding the variability of pollen as affecting comparable results can, of course, be similarly applied if small instead of large pistils are used for emasculation, (Table 9). Heinicke (47) has shown that the set of fruit is greatly influenced by the vigor of the spurs and we have found this to be true in our studies. This important fact should be taken into consideration, especially when dealing with small numbers. As has been

stated, trees of different ages and vigor vary greatly in their "normal set". It is a self-evident fact that this variability should be considered when comparing the value of the same pollenizers on different varieties, or when comparing different pollenizers on the same variety. It is also clear from the above evidence, that results secured under different conditions in different years, should not be totaled or averaged. Certain results secured will also be misleading, if they are averaged, unless all conditions of the tests are uniform and similar. Fletcher's (37) review on, "Methods of Crossing Fruits", is interesting in this connection.

Of course, errors from the examples stated would be greatly reduced, if large numbers of blossoms were used in all tests. Unfortunately the time allowed for pollination purposes, under field conditions, is limited to only a few days in the year and all investigators are anxious to make as many different investigations as possible. As a result, large numbers are not always used, nor are all the variable factors noted as closely as possible. Since the above mentioned factors might influence pollination studies so decidedly, they may explain several apparent contradictions in pollination results either of the same investigator or between different investigators in differnt parts of the country. Of course, there are probably other factors which may be found to influence results in addition to the ones mentioned in this paper.

This report is made at this time, not in a spirit of criticism, but rather in the hope that the above mentioned factors will be more closely noted by future investigators and that a complete record of their varying factors and conditions, such as temperature, age of tree and details of work, will be recorded with the results, so that it will be possible to compare them with the results of others in a more accurate manner. The author realizes that criticisms can be made of his methods and even that some of the points emphasized may be found not to be as important as they appear now, but he will be satisfied if this paper stimulates future investigators in pollination problems to practice special care in avoiding all varying factors which might affect the accurateness of their results. Only in this way can a solution of certain pollination problems be hastened.

Summary

1. Apple pollination studies have been carried on in Maryland in connection with fruit-breeding investigations for the last 15 years. During the last three years, special attention has been given to apple pollination studies.

2. Of sixty-six varieties of apples studied, 45 were self-sterile, 12 were self-fertile, and 9 were partially self-fertile.

3. The rating of a variety as to being either self-sterile or self-fertile appears to vary in different sections.

4. Bagging, without brushing of the flowers, is apparently satisfactory as a test for self-sterility versus self-fertility.

5. The average blooming season over a series of years for apple varieties is shown. The blossoming periods of many of our common varieties overlap sufficiently to insure cross-pollination.

The blooming period of most apple varieties generally extends over eight or nine days.

6. Different varieties used as pollinizers, vary considerably in their ability to cause a set of fruit when used on the same (female) tree. Some varieties were inter-sterile in both years that the tests were made.

7. In one year's test there was no consistent correlation among different varieties, between the amount of pollen germination in sugar solutions and self-sterility. Stayman Winesap, however, which rarely caused a set of fruit with any of the varieties, showed practically no germination.

8. The source and nature of pollen may greatly influence pollination results.

9. The size of blossom buds selected for emasculation may greatly influence pollination results.

10. The delay between the time of emasculation and cross-pollination may greatly influence pollination results.

11. Apple pollen will remain healthy and viable for long periods if kept dry and at proper temperatures.

12. Pollen can withstand much lower temperatures than pistils without apparent injury. Pollen from blossoms in which the pistils have been killed by moderately low temperatures will germinate satisfactorily in sugar solutions.

13. Weather conditions may play a very important part in pollination results. In general, the time of day at which the work is done, does not play a very important part unless decided weather changes have taken place.

14. The practical application of many of the above factors to pollination studies suggests possible explanations of several apparent contradictions in pollination results either of the same investigator in one state, or between different investigators in different parts of the country. The necessity of using great care in pollination methods is clearly shown.

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The Effects of Certain Soil Treatments on the Formation of Fruit Buds in Peaches

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THE experiments, the results of which form the subject of this paper, were performed in a peach orchard located in Richland County in the southern third of the state of Illinois. This is the same orchard which the writer described in a paper presented to this Society on the "Responses of a Young Peach Orchard to Certain Cover Crops and Fertilizer Treatments" at its meeting in Chicago in 1920. Reviewing briefly the conditions under which the experiment was performed and the arrangement of the plots, it should be said first that the location is near the east side of the state of Illinois and in the same latitude as the city of St. Louis. The orchard slopes gently and regularly toward the west. The site is on the side and near the top of a ridge of somewhat unusual prominence for a prairie country. The soil is technically described as a grey silt loam on tight clay subsoil. The surface drainage is good and the under drainage fair, but by no means ideal. The soil is low in humus, nitrogen, phosphorus and lime, and relatively high in potassium. Illinois soil analyses show that this type contains about 2700 pounds of nitrogen, 750 pounds of phosphorus, and 24,800 pounds of potassium per acre in the surface soil.

The orchard is divided into 43 major plots, each of which includes 16 trees. The plots are arranged in 3 ranges, each range separated from the adjoining one by a wide space where one row of trees was omitted. The plots in each range are separated by division rows of a separate variety. Each plot consists of two rows of trees of the variety J. H. Hale. The separating rows are Elberta. The trees were started from June buds planted in the spring of 1917. An unusually uniform stand was obtained and the orchard has had no set-back due to unfavorable weather, insect or disease visitation, or other accident to interfere with an impartial response to the treatments given.

In 1920, following a favorable winter for both wood and fruit buds, the orchard set a good crop in its fourth season of growth and showed differences between the yields of certain of the plots large enough to bear significantly upon certain orchard practices

with reference to cultivation, cover crops, and fertilization, for young trees growing on similar types of soil.

Certain of the effects of the treatments as indicated by the crop of 1920 were summarized as follows:

1. Cow peas used as a cover crop planted from July 10 to 15 were detrimental to the growth and yield of peach trees as compared with clean cultivation alone.
2. The addition of a fertilizer carrying soluble potassium completely corrected the difficulty.
3. The addition of a fertilizer carrying soluble nitrogen partly corrected the difficulty.
4. The addition of a fertilizer carrying phosphorus gave uncertain results.
5. The addition of both nitrogen and potassium somewhat increased the yield of cover crop plats over clean cultivation.
6. Rye following cow peas, used as a winter cover, was very detrimental, almost deadly, in effect.

The winter of 1920—1921 was mild and the fruit buds came through the winter in excellent condition. They bloomed early, during a period of weather moderately favorable for pollination, but just at the close of the blossoming period a severe freeze destroyed about 70 per cent of the blossoms. One week later another freeze destroyed the small fruits which had set. Therefore, no crop record was obtained in 1921. During blossoming time, however, a careful estimate was made of the amount of bloom present on the trees in the different plots, this estimate being the basis for the paper herewith presented.

The estimate was made by two parties, the writer and an assistant, working independently, each making two separate estimates, a total of four estimates. A general survey of the orchard was made and several trees with heavy crops of blossoms were selected as representing maximum amounts of bloom. Trees with no blossoms were graded as zero and the maximum trees as one hundred, each individual tree in the orchard being graded on this scale to the best of the recorder's judgment. As the effect of the treatments should be gauged not only in percentage of bloom present on the trees, but also in the total amount of bloom, it was also necessary to make a similar estimate of the relative size of the tree. This estimate was made on a scale of 10 and the amount of bloom determined by multiplying the bloom estimate by the size estimate.

From the standpoint of fruit bud formation such a record may be more accurate than a crop production record because it deals directly with the subject under investigation. Many factors such as insect and disease attacks, unfavorable weather, and mistakes in judgment in orchard management may easily result in the loss of part of the crop after blossoming time, thus preventing a crop production record from being an accurate gauge of the effects of the treatments on fruit bud production. Of the accuracy of the method the writer is assured as it plainly confirmed the easily observed differences between many of the plots; and orchardists who visited the plots during blossom time were able to note, without difficulty, the conspicuous differences which the recorded results later confirmed.

Comparing all clean cultivated plats with all cow pea cover crop plats (16 of each) regardless of fertilizer treatments, the clean cultivated plats produced 47 per cent more blossoms than the cow pea cover crop plats. Clean cultivation unassisted by fertilizers produced 300 per cent more blossoms than cow pea cover crop plats unassisted by fertilizers other than lime and rock phosphate. All cow pea cover crop plats unless otherwise stated, were treated with limestone and rock phosphate. Clean cultivated plats were not so treated.

Sodium nitrate used alone increased the amount of bloom under clean cultivation by 26 per cent and in cow pea cover crop plats by 15 per cent.

Potassium sulphate increased the amount of bloom under clean cultivation by 37 per cent *and in cow pea cover crop plats by 330 per cent.* The substitution of muriate of potash for potassium sulphate in certain plats in 1920 did not affect the responses of these plats in 1921, but further observations are necessary to prove that the responses of the trees to the two potassium carriers will continue the same in ensuing seasons.

Phosphorus was applied as rock phosphate, bone meal, Thomas phosphate, and acid phosphate. The phosphorus treated plats under clean cultivation averaged 9 per cent more bloom than the adjoining check plats. Acid phosphate, however, increased the yield by 17 per cent and Thomas phosphate by 34 per cent.

Stable manure increased the yield of blossoms in a clean cultivated plat by 23 per cent over the adjoining check *and in a cow pea cover crop plat by 300 per cent over the adjoining check.* All stable manure plats balanced against all corresponding unfertilized checks gave an increased production of 73 per cent.

Nitrogen added to potassium (sodium nitrate to potassium sulfate) increased the yield of blossoms by 46 per cent over potassium alone in clean cultivated plats, *but produced no increase on cow pea cover plats.*

Potassium added to nitrogen (potassium sulfate to sodium nitrate) increased the yield of blossoms by 34 per cent over nitrogen alone in clean cultivated plats, *and by 261 per cent in cow pea cover crop plats.*

The most profitable increases in fruit in 1920 and in fruit buds in 1921, occurred under clean cultivation where the trees were fertilized with sodium nitrate and potassium sulfate.

The Set of Fruit in Apple Crosses*

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Proper pollination in the orchard is now regarded as of considerable importance in fruit production. While this phase of

* These crosses were made while the writer was connected with the Minnesota Experiment Station. Most of the routine of crossing was done by Charles Haralson assisted by H. J. Beaumont, Elmer Haralson, and John Bushnell. Published with the approval of the Director as Paper No. 308 of the Journal Series of the Minnesota Agricultural Experiment Station.

fruit growing has been given chief attention in the last two decades, it appears to have been first recognized, according to Chittenden ('14), by Swayne working with the pear in 1822. Since that time the experiments of Darwin have given sex and pollination studies in plants great impetus. His work has been followed more specifically in fruits by Waite ('94), Beach ('92), Goff ('94) and many others working more recently. This general question it should be observed, has its setting in the growth of the knowledge of sex in plants the first conception of which appears to be very ancient.

From the standpoint of the fruit grower, many of the important phases of the pollination problem have been recognized. Among these may be mentioned nutrition, the relative time of bloom, self—and cross—sterility, the methods of pollen dissemination under orchard conditions, and the effect of weather upon the processes taking place at bloom. Studies of the relationship of the leading varieties, however, both as pollen or pistillate parent needs further attention on a larger scale, under widely varying conditions. The controlled crosses made so far indicate that the relationship of varieties in the orchard can be determined by this method.

The crosses reported in this paper were made under glass in the hardy apple breeding investigation at the Fruit Breeding Farm of the University of Minnesota. The trees were grown in tubs. During winter they were stored in an unheated root cellar and in early spring were moved into the greenhouse under growing temperature. By bringing the trees in at different times the period of bloom of each group could be controlled and the crossing work in this way held within bound. By following this method of proceedure the routine of crossing each year extended from late March to early May.

The care of the trees followed the usual greenhouse methods. They were grown on Paradise stock and pruned back to low heads and a compact framework. Further pruning consisted of cutting back the terminal growth to six to twelve inches first after the fruit had set and again the next spring when brought into the greenhouse. The trees were planted in a dark rich loam soil and each spring, and sometimes in early summer, fertilizer was added—somtimes nitrate of soda and again liquid manure or acid phosphate, potash and ground bone. The trees were given the usual spray treatments in the greenhouse. Watering and other items of care followed the regular routine.

In making the crosses there was little departure from the usual method except that under glass, bagging or other coverings were unnecessary owing to the absence of insects and especially bees. The varieties included in the tables were as far as known true to name and every precaution was taken to avoid errors in the application of pollen and in placing labels. In many instances more than one cross was made on a tree. This accounts partly for the small number of flowers crossed in some combinations. It

should be pointed out, however, that in some of the cross-sterile combinations the productive crosses on the same tree serve as a check to the technique and condition of the trees upon which the crosses were made. Since there was no covering of the flowers either before or after pollination, emasculation was generally done just before the petals broke. The trees were gone over as a rule a number of times in order to emasculate the later flowers to open. Likewise, in pollination, where there was considerable difference in the time of maturity of the anthers, as many as four pollinations were made. It will be seen then that under glass, while the number of flowers is limited on account of the size of the tree, this is largely counterbalanced by the absence of covering and greater care in technique, especially the time of pollination.

By referring to the following tables it will be noted that while both of the self and cross relationship has been studied, chief attention has been given to the crosses. In Table I record has been made of the number of flowers pollinated, the number set, the number which matured, and both the number of plump and aborted seeds. The number of flowers crossed was determined after emasculation and pollination rather than before, in order to allow for those eliminated by injury or accidental removal. The set of fruit was determined after there was sufficient enlargement at the base of the pistil to ascertain definitely that fertilization had taken place, but before the June drop. The number of fruits which matured was determined at the time of picking. The difference between the number set and the number which matured, is due primarily to loss from the June drop, but it also includes accidental loss from all other causes. While the division line cannot be definitely drawn between the plump and aborted seeds, the doubtful cases were relatively few. The aborted group includes those seeds in which there was an enlargement of the seed coats beyond the characteristic dimensions of the unfertilized ovules, but in which there is only a partial development of the cotyledons and embryo. These would float if placed in water.

The order of the crosses in Table I is alphabetical to the pistillate parent. Under each of these categories the crosses are arranged further according to the year in which they were made, and then alphabetically according to the pistillate parent under each year. The number of each tree is given in the columns at the left. By following these numbers from year to year the crosses made on each tree can be determined. All of the tree numbers, however, may not appear for each season because many of the trees did not produce flowers every year. The data for 1921 were omitted because a break-down in the water system made it practically impossible to bring the trees through the season under the conditions of growth characteristic of former years.

The system of numbering the trees has no particular significance in connection with the subsequent performance. The trees were started in tubs when small and the first to come into bloom, about 70 in all, were given numbers in 1918. Subsequently numbers were given to each tree as they were put into tubs;

When all of the trees are arranged into a table to show the number of times each tree has produced flowers, the following condition is found: Of the 70 or so which bloomed the first year, 23 bloomed the two following seasons. In all, 42 bloomed two years in succession, 81 one year only, and two bloomed the first and third year of the experiment.

TABLE I

Three years' Records of Apple Crosses—1918, 1919 and 1920

Tree Number	Cross	Year cross was made	Number flowers pollinated	Number fruits set	Number fruits matured	Number plump seeds	Number aborted seeds
10	Black Ben Davis x Oldenburg	1919	130	27	2	9	7
40	" " " x "	1919	165	32	14	22	68
176	" " " x "	1919	65	20	11	35	29
176	" " " x "	1920	211	0	0	0	0
40	" " " x "	1920	140	2	0	0	0
199	" " " x Hibernal	1920	42	8	1	5	4
10	" " " x Jonathan	1918	81	11	0	0	0
46	" " " x King David	1918	99	6	0	0	0
46	" " " x Okabena	1919	112	15	3	4	20
10	" " " x "	1920	240	0	0	0	0
153	" " " x "	1920	39	0	0	0	0
40	" " " x Wealthy	1918	38	7	0	0	0
187	Boiken x Charlamoff	1920	167	45	16	94	8
167	Charlamoff x Black Ben Davis	1919	28	19	17	98	20
58	" x Delicious	1918	5	2	1	6	4
144	" x "	1920	26	4	3	14	0
58	" x "	1920	4	0	0	0	0
20	" x Jonathan	1918	5	0	0	0	0
58	" x "	1919	120	27	22	139	27
144	" x "	1920	44	9	7	30	4
177	" x King David	1919	14	0	0	0	0
144	" x Stayman Winesap ..	1920	20	1	1	9	0
	" x " " .	1920	180	10	0	0	0
133	Colorado Orange x Oldenburg	1920	533	44	15	36	72
63	Delicious x Charlamoff	1918	9	0	0	0	0
119	" x "	1919	22	0	0	0	0
97	" x "	1920	30	0	0	0	0
42	" x Oldenburg	1918	4	0	0	0	0
17	" x Oldenburg	1918	113	0	0	0	0
48	" x "	1918	56	0	0	0	0
17	" x "	1919	33	1	1	7	0
18	" x "	1919	420	0	0	0	0
84	" x "	1919	9	2	0	0	0
172	" x "	1919	70	0	0	0	0
174	" x "	1919	190	0	0	0	0
174	" x "	1920	436	40	33	75	139
100	" x "	1920	179	2	2	15	0
148	" x "	1920	314	2	0	0	0
48	" x "	1920	84	0	0	0	0

Tree Number	Cross	Year cross was made	Number flowers pollinated	Number fruits set	Number fruits matured	Number plump seeds	Number aborted seeds
63	" x Hibernal	1919	48	14	10	52	26
155	" x "	1919	4	0	0	0	0
49	" x Lady	1918	20	0	0	0	0
80	" x Northwestern Greening	1920	64	0	0	0	0
100	" x Okabena	1919	48	6	6	46	2
109	" x "	1919	105	9	9	63	3
146	" x "	1920	90	0	0	0	0
	" x "	1920	236	0	0	0	0
18	" x Patten Greening	1920	530	0	0	0	0
18	" x Wealthy	1918	26	0	0	0	0
48	" x "	1919	120	19	3	11	13
130	" x "	1919	3	0	0	0	0
55	Duchess x Black Ben Davis	1919	53	6	6	51	5
57	" x " " "	1919	50	14	13	89	6
55	" x Colorado Orange	1920	50	11	11	75	9
55	" x Delicious	1918	103	13	11	62	14
57	" x "	1918	4	1	1	8	2
13	" x "	1919	85	16	13	95	14
45	" x "	1919	45	2	0	0	0
57	" x "	1919	240	56	54	391	22
170	" x "	1919	35	2	2	10	3
185	" x "	1920	36	9	3	23	2
57	" x "	1920	87	29	17	108	11
45	" x Grimes Golden	1918	68	0	0	0	0
55	" x " "	1919	65	23	19	142	7
106	" x " "	1919	65	20	12	78	25
55	" x Gilbert Winesap	1919	31	19	14	73	2
122	" x " "	1920	187	15	5	16	0
36	" x Jonathan	1918	48	0	0	0	0
122	" x "	1919	82	3	2	14	5
185	" x "	1920	93	40	15	116	7
57	" x "	1920	147	51	24	191	6
	" x "	1920	30	3	2	14	3
197	" x "	1920	97	50	22	131	5
29	" x King David	1918	137	7	7	53	16
29	" x " "	1919	31	10	8	44	13
55	" x " "	1919	72	21	15	119	8
83	" x " "	1920	152	0	0	0	0
106	" x " "	1920	160	2	0	0	0
13	" x " "	1920	124	6	0	0	0
55	Oldenburg x King David	1920	216	28	9	47	2
2	" x Stayman Winesap	1918	5	0	0	0	0
13	" x " "	1918	131	1	0	0	0
55	" x " "	1920	270	49	25	111	13
57	" x " "	1920	75	18	7	23	0
29	" x " "	1920	147	0	0	0	0
45	" x " "	1920	140	3	0	0	0
43	Evelyn x Oldenburg	1918	5	0	0	0	0
128	" x "	1919	8	1	1	1	1
128	" x "	1920	9	6	2	6	4
171	" x "	1920	144	0	0	0	0

Tree Number	Cross	Year cross was made	Number flowers pollinated	Number fruits set	Number fruits matured	Number plump seeds	Number aborted seeds
128	" x Hibernal	1919	21	0	0	0	0
145	" x Wealthy	1920	21	18	0	0	0
65	Fallawater x Oldenburg	1918	12	8	5	35	12
65	" x Okabena	1919	15	8	0	0	0
65	" x Patten Greening	1920	372	22	7	16	4
65	" x Stayman Winesap	1918	6	0	0	0	0
65	" x " "	1919	50	2	2	10	10
65	" x Wealthy	1919	85	2	0	0	0
25	Grimes Golden x Oldenburg	1918	556	58	58	454	25
38	" " x "	1919	44	20	11	81	5
25	" " x "	1920	170	55	30	155	11
104	" " x "	1920	405	0	0	0	0
25	" " x Okabena	1919	120	38	21	163	14
38	" " x Patten Greening	1920	40	0	0	0	0
38	" " x Wealthy	1918	89	7	4	34	3
61	Gilbert Winesap x Charlamoff	1920	76	28	1	5	2
61	" " x "	1920	436	18	0	0	0
61	" " x Hibernal	1919	720	0	0	0	0
61	" " x "	1920	168	32	1	4	1
201	Hibernal x Colorado Orange	1920	5	2	1	9	0
19	" x Delicious	1918	8	1	1	5	0
114	" x "	1919	8	1	0	0	0
126	" x "	1919	25	1	0	0	0
114	" x "	1920	95	0	0	0	0
201	" x "	1920	160	26	6	21	13
19	" x Grimes Golden	1919	66	2	0	0	0
184	" x Jonathan	1920	17	2	0	0	0
201	" x "	1920	37	14	2	12	3
19	" x King David	1920	43	0	0	0	0
184	" x Stayman Winesap	1920	5	0	0	0	0
37	Jonathan x Charlamoff	1918	5	0	0	0	0
52	" x "	1918	153	12	8	47	2
157	" x "	1920	9	1	1	5	1
196	" x "	1920	5	1	1	6	1
64	" x Oldenburg	1918	5	0	0	0	0
124	" x "	1919	190	26	1	3	1
168	" x "	1919	84	21	13	64	29
23	" x "	1919	115	47	39	195	17
30	" x "	1919	16	4	4	26	2
35	" x "	1919	58	12	5	38	0
52	" x "	1919	21	10	7	49	2
70	" x "	1919	25	5	2	11	2
164	" x "	1919	9	0	0	0	0
23	" x "	1920	193	58	38	171	9
124	" x "	1920	367	25	5	20	2
120	" x "	1920	88	0	0	0	0
	" x "	1920	55	4	0	0	0
191	" x "	1920	278	86	57	396	13
35	" x "	1920	24	0	0	0	0
110	" x Hibernal	1919	40	2	2	9	0
164	" x "	1920	107	19	0	0	0
110	" x "	1920	146	24	11	62	3

Tree Number	Cross	Year cross was made	Number flowers pollinated	Number fruits set	Number fruits matured	Number plump seeds	Number aborted seeds
186	" x Hibernal	1920	28	11	10	93	5
23	" x Okabena	1918	157	18	0	0	0
30	" x "	1918	16	3	3	0	0
70	" x "	1918	117	3	3	17	1
168	" x "	1919	130	23	9	46	17
168	" x Patten Greening	1920	94	0	0	0	0
	" x " "	1920	78	45	28	199	58
198	" x " "	1920	115	45	26	163	9
103	" x Wealthy	1919	95	15	13	87	10
120	" x "	1919	100	30	16	109	15
9	King David x Black Ben Davis	1918	217	6	0	0	0
118	" " x Charlamoff	1919	92	11	4	32	3
9	" " x "	1919	150	4	6	41	2
161	" " x "	1920	5	0	0	0	0
5	" " x Oldenburg	1918	96	8	6	45	1
15	" " x "	1918	62	2	0	0	0
44	" " x "	1918	26	3	0	0	0
50	" " x "	1918	27	1	0	0	0
117	" " x "	1919	40	7	7	45	0
3	" " x "	1919	6	1	0	0	0
12	" " x "	1919	192	39	39	200	110
15	" " x "	1919	93	23	23	136	4
99	" " x "	1919	9	1	1	7	0
123	" " x "	1919	170	3	2	14	1
175	" " x "	1919	130	13	9	15	27
99	" " x "	1920	15	9	6	40	0
3	" " x "	1920	21	0	0	0	0
117	" " x "	1920	92	0	0	0	0
44	" " x "	1920	6	0	0	0	0
131	" " x "	1920	144	5	0	0	0
131	" " x Grimes Golden	1919	31	2	1	7	0
39	" " x Hibernal	1918	21	0	0	0	0
5	" " x Milwaukee	1919	4	0	0	0	0
3	" " x Okabena	1918	136	2	0	0	0
12	" " x "	1918	244	7	0	0	0
44	" " x "	1919	50	8	7	39	10
175	" " x "	1920	390	0	0	0	0
50	" " x "	1920	292	0	0	0	0
15	" " x "	1920	17	0	0	0	0
	" " x Wealthy	1919	180	4	0	0	0
138	Lady x Oldenburg	1920	340	2	0	0	0
1	" x Wealthy	1918	6	5	4	32	0
8	" x "	1918	145	55	52	438	5
111	Milwaukee x Jonathan	1919	195	40	40	194	92
111	" x King David	1920	132	4	0	0	0
51	" x University	1918	4	0	0	0	0
79	McIntosh x Oldenburg	1920	48	0	0	0	0
21	" x Patten Greening	1920	25	0	0	0	0
21	" x Wealthy	1918	14	0	0	0	0
85	Northwestern Greening x Oldenburg	1920	149	0	0	0	0
107	" " x "	1920	347	0	0	0	0
160	" " x Grimes Golden	1920	36	0	0	0	0

Tree Number	Cross	Year cross was made	Number flowers pollinated	Number fruits set	Number fruits matured	Number plump seeds	Number aborted seeds
6	" " x Wealthy	1918	6	0	0	0	0
16	" " x "	1918	4	0	0	0	0
85	" " x "	1919	4	0	0	0	0
107	" " x "	1919	130	3	3	21	3
143	" " x "	1920	82	8	4	22	3
107	" " x "	1920	75	0	0	0	0
34	Okabena x Black Ben Davis	1920	43	0	0	0	0
60	" x " " "	1920	60	0	0	0	0
11	" x Delicious	1919	80	21	14	108	3
34	" x "	1919	165	8	3	2	26
60	" x "	1919	120	24	13	101	13
115	" x "	1920	265	2	0	0	0
115	" x Grimes Golden	1919	120	23	21	119	10
200	" x Gilbert Winesap	1920	71	25	10	61	11
200	" x Jonathan	1920	43	21	4	30	5
34	" x King David	1920	147	0	0	0	0
11	" x " "	1920	168	5	0	0	0
34	" x Northwestern Greening	1920	122	0	0	0	0
11	" x Stayman Winesap	1918	79	6	6	33	5
34	" x " "	1918	146	3	3	25	3
60	" x " "	1918	13	2	2	10	5
87	" x " "	1919	15	0	0	0	0
87	" x " "	1920	20	0	0	0	0
200	" x " "	1920	54	21	12	92	8
112	Patten Greening x Colorado Orange	1920	111	15	14	86	0
86	" " x Oldenburg	1920	230	0	0	0	0
178	" " x Delicious	1920	110	22	12	70	12
112	" " x Gilbert Winesap	1920	165	7	7	37	0
32	" " x Jonathan	1918	250	25	22	193	35
113	" " x "	1920	67	10	0	0	0
86	" " x King David	1919	8	1	0	0	0
113	" " x Stayman Winesap	1920	124	2	2	11	0
178	" " x " "	1920	131	10	3	8	5
112	" " x Wealthy	1919	23	0	0	0	0
189	Patten Greening x Wolf River	1920	102	34	25	96	26
101	Rome Beauty x Oldenburg	1919	145	47	40	322	3
125	Rome Beauty x Hibernal	1919	5	1	1	6	0
	" " x "	1920	4	0	0	0	0
33	Stayman Winesap x Charlamoff	1919	19	4	4	8	17
22	" " x Oldenburg	1918	51	5	0	0	0
26	" " x "	1918	81	1	0	0	0
22	" " x "	1919	67	15	11	22	41
28	" " x "	1919	132	24	11	24	50
121	" " x "	1919	9	1	0	0	0
121	" " x "	1920	157	28	21	59	63
62	" " x "	1920	465	14	14	100	15
62	" " x Hibernal	1920	29	10	3	12	13
26	" " x "	1920	73	0	0	0	0
33	" " x King David ...	1918	99	2	2	0	0
28	" " x Okabena	1918	18	2	0	0	0
26	" " x "	1919	110	9	9	38	28
62	" " x "	1919	19	0	0	0	0

Tree Number	Cross	Year cross was made	Number flowers pollinated	Number fruits set	Number fruits matured	Number plump seeds	Number aborted seeds
62	" " x Patten Greening	1920	152	0	0	0	0
27	University x Jonathan	1918	13	0	0	0	0
173	" x King David	1919	20	1	0	0	0
47	Wealthy x Delicious	1919	60	19	10	71	4
105	" x "	1919	136	26	6	33	15
129	" x "	1919	22	13	9	56	8
31	" x Grimes Golden	1919	25	19	14	99	27
127	" x Gilbert Winesap	1919	44	4	4	13	1
159	" x " "	1920	94	20	14	80	9
134	" x " "	1920	35	8	8	24	0
190	" x " "	1920	217	25	10	50	6
127	Wealthy x King David	1920	312	1	0	0	0
7	" x Lady	1918	102	5	5	36	2
150	" x Okabena	1919	8	0	0	0	0
4	" x Stayman Winesap	1918	8	2	1	7	2
47	" x " "	1918	11	0	0	0	0
4	" x " "	1920	145	0	0	0	0
105	" x " "	1920	130	0	0	0	0
47	" x " "	1920	15	0	0	0	0
132	" x " "	1920	5	0	0	0	0
193	" x Wolf River	1920	217	46	20	160	9
188	Wilson Red June x Patten Greening	1920	56	4	4	9	1
67	Winter Banana x Oldenburg	1920	280	27	0	0	0
116	" " x Hibernal	1919	6	2	0	0	0
116	" " x Okabena	1919	76	26	2	13	0
14	Wolf River x Delicious	1918	4	3	0	0	0
169	" " x Wealthy	1919	55	3	0	0	0
78	" " x "	1920	38	5	1	4	13
136	" " x "	1920	25	9	0	0	0
73	" " x "	1920	265	45	5	33	16
169	" " x "	1920	8	0	0	0	0
	Totals for	1918	3999	303	205	1540	137
	Totals for	1919	7570	1103	716	4270	948
	Total for	1920	16381	1467	644	3560	639
	Grand total for three years		27950	2873	1565	9370	1714

For the investigator interested in the pollination problem a detailed analysis of the data presented in Table I is unnecessary. Each parental combination has its own significance. There are, however, some features which may be emphasized briefly since the limits of this paper do not permit a complete analysis.

In general it will be seen that the percentage of fruit to set is quite variable ranging from zero to 30 per cent in a number of crosses, with extremes as high as 57 per cent in Jonathan X Patten Greening, where 78 flowers were pollinated. Using the grand total as a basis for comparison, it will be seen that of the 27,950 flowers pollinated, 2873 set, or 10.3 per cent. Based

upon the number of flowers pollinated the number of fruit matured in all crosses was 5.6 per cent. The set for all of the crosses in 1918 was 7.57 per cent, 14.5 per cent in 1919, and 8.95 per cent in 1920. The number of plump seed per mature fruit is somewhat more constant than the set of fruit. In 1918 the average number was 7.51; in 1919, 5.96; and in 1920, 5.53 compared with 5.99 for the grand total. The large number of aborted seeds in 1919, the year of the heaviest set, is an interesting feature of the crosses.

By following the different crosses through the table, many irregularities will be observed in the set of fruit. In some instances such as Black Ben Davis X Okabena (1920), Delicious X Patten Greening (1920), or Gilbert Winesap X Hibernal (1919), a large number of flowers have been pollinated, but none have set. Other trials show that the first two of these combinations are cross-fertile. These irregularities correspond quite closely with those observed in the crosses made under field conditions, such as those reported by Lewis and Vincent (1909), Morris (1921) and Gowen (1920), and probably are due to similar causes.

The production of bloom does not nesessarily correspond with fruit production. This is strikingly illustrated in a number of instances. The crosses between King David and Oldenburg in 1919 and 1920, illustrate what might be called alternate bearing. The trees, 40 and 176, show a similiar behavior in the cross between Black Ben Davis and Oldenburg. In contrast to these the Delicious X Oldenburg combinations have set poorly for three years in succession—tree 174 in 1920 being an exception even to its own record in 1919 when 190 flowers failed to set fruit. The reciprocals of this cross, however, Oldenburg X Delicious have set well. Oldenburg as a pollen parent can be checked in other crosses than on Delicious by referring to Table I.

One of the most conspicuous features in the 277 crosses recorded, is the large number of instances in which all or practically all of the pistils which were pollinated, failed to set. In the cross sterile combinations one cross on a tree may fail to set, while another cross fertile combination would set normally on the same tree. This condition has been encountered in a few instances in the early work and is especially noticeable in the plum. On the other hand some trees failed to set with more than one pollen parent as is shown by Fallawater (tree 65) in 1919. In still other instances, a variety will set fruit with three or more varieties as in the case of Oldenburg (tree 55) in 1919. Grimes Golden (tree 25) has matured a good crop of crosses each of the three years under observation.

These instances deal supposedly with the record of the pistillate parent. In some instances the pollen appears to be the decisive factor in setting as illustrated by the setting where Oldenburg pollen is used on Delicious. This is in line with the experiments of Knowlton (21) in which he shewed that pollen germination may vary from year to year from the same form.

The set of fruit when some of the leading varieties were used as the pollen parent is shown in Table II.

TABLE II.

The Relative Effectiveness of Four Varieties as Pollen Parents

	Number flowers Pollinated	Per cent set	Per cent matured	Average Number Plump seeds per fruit
Oldenburg as pollen parent on 14 varieties	9663	9.28	5.65	5.37
Delicious as pollen parent on 8 varieties	1928	15.61	9.28	6.61
Jonathan as pollen parent on 8 varieties	1369	22.35	11.91	6.57
Wealthy as pollen parent on 12 varieties	1637	14.36	6.41	7.53

This summary was taken directly from Table I. While there is considerable difference in the percentage to set in the different varieties, the average number of seeds per fruit is more constant although following the percentage set closely.

In comparison to the crosses the results secured by self-pollinating a number of the leading varieties is markedly different and corresponds very closely to the general condition reported by others. These tests have been brought together in Table III.

TABLE III.

The Set of Fruit in Self Pollinated Apple Varieties

Tree Number	Cross	Year Cross was made	Number flowers pollinated	Number flowers set	Number fruit	Number Plump seeds	Number Aborted seeds
46	Black Ben Davis Selfed	1919	48	9	0	0	0
	Delicious Selfed	1918	35	0	0	0	0
17	Delicious Selfed	1919	9	0	0	0	0
100	Delicious Selfed	1919	21	1	1	8	0
174	Delicious Selfed	1919	8	0	0	0	0
170	Oldenburg Selfed ...	1920	217	0	0	0	0
128	Evelyn Selfed	1919	14	0	0	0	0
65	Fallawater Selfed ...	1918	16	0	0	0	0
65	Fallawater Selfed ...	1919	90	2	0	0	0
61	Gilbert Winesap Selfed	1919	26	0	0	0	0
19	Hibernal Selfed	1919	19	0	0	0	0
23	Jonathan Selfed ...	1919	44	1	0	0	0
124	Jonathan Selfed ...	1919	120	0	0	0	0
103	Jonathan Selfed ...	1919	24	3	0	0	0
50	King David Selfed ..	1919	140	0	0	0	0
104	King David Selfed ..	1919	55	0	0	0	0
111	Milwaukee Selfed ...	1919	32	0	0	0	0

107 Northwestern Greening Selfed	1919	9	1	0	0	0
60 Okabena Selfed	1919	38	1	0	0	0
26 Stayman Winesap Selfed	1919	16	2	2	5	5
76 Stayman Winesap Selfed	1919	4	0	0	0	0
22 Stayman Winesap Selfed	1919	17	0	0	0	0
105 Wealthy Selfed	1919	32	0	0	0	0
67 Banana Selfed	1918	66	3	0	0	0
					13	

It will be seen from an inspection of this table that there is a surprisingly small set under the conditions of self pollination. The pollinations were carefully made and in many instances were repeated several times. Usually a single limb on a tree was selected for the self pollinations and in many cases the other limbs of the trees were crossed with other varieties and set. By means of the tree numbers and the year, the record of each tree upon which self pollinations were made can be followed in Table I. The 23 fruits set and the tree matured out of 1065 flowers is far too slight for a crop under orchard conditions.

It will be interesting in concluding to point out some general considerations regarding these trees. Mention has been made of the fact that of the 200 trees or so under observations that a number have not produced flowers. Fifty-five trees in the series fall within this group which is made up in general of the same varieties which have fruited. Another stage in the condition of these trees appears to be indicated by those which have produced flowers more or less abundantly, but which do not set fruit. Summarizing these instances in Table I, it will be seen that there are 85 of them which involve 7010 flowers or about one-fourth of the total number. A number of factors may have a bearing upon this condition. The trees may have been either exhausted by previous fruiting, or under greenhouse conditions water deficiency may start abscission processes in the flowers which would drop later. Whatever the cause may be, it is evident that under greenhouse conditions as under field conditions, flower production does not necessarily mean fruit production. Again, in going through the column indicating the percentage set, many instances will be found where there is a marked loss between the set and maturity. Note the cross between Gilbert Winesap and Charlamoff (tree 61), or between Banana and Oldenburg (tree 67) in this connection. Deficient watering at critical times may be the primary cause of this drop. Finally, when the number of aborted seeds in proportion to the plump seeds is followed through the different crosses, considerable variation is encountered. This condition may have its setting in both nutrition and in the genetic combination.

It will be interesting to examine the results of these crosses from the standpoint of their treatment in the greenhouse. Pruning the trees when they were brought into the greenhouse would tend to induce a more strongly vegetative growth. Then when

they were pruned back again at about the time the terminal growths were completed, they were thrown still further in this direction. In addition to the pruning, the application of nitrogen in the form of either liqiud manure or nitrate of soda, would still further add to the vegetative condition (Krause and Kraybill'18). If there is restricted root space as in the case of Gilbert Winesap (tree 61 in 1919 and 1920), apparently a condition is brought about comparable to ringing as shown by Alderman and Auchter ('16). Howe ('14), Drinkard ('15) and others in which flowers may be produced, but no fruit. The condition of the tree is apparently more clearly indicated in the greenhouse by the performance record, since the influence of weather and genetic combinations are known for the most part and are consequently reduced to a minimum. Therefore, it appears that before results in the greenhouse are given any more weight than crosses outside, the care of the trees will have to be given more attention especially in view of the fact that in the greenhouse artificial conditions may be brought about for some varieties by either high or low temperatures, or by greater humidity.

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Results From Self-Pollination of Apple Flowers

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IN apple breeding work at the Illinois Experiment Station, an effort has been made to self-pollinate some flowers every season. No extensive operations have been undertaken, but only such limited work as could be conveniently added to the regular schedule of hybridization.

The first self-pollinations were made in 1909 and, with the exception of 1910, some self-pollinations have been made each year since. Thus far flowers have been self-pollinated on 117 different apple forms which classify and divide into three groups such as recognized orchard varieties, 30; crabs and crab-like forms of the genus, 47; and hybrid seedlings, 40.

Work on the orchard varieties and on most of the crabs was done on trees in orchard, but on most of the hybrid seedlings and some of the crabs it was done on potted trees in the greenhouse.

The aggregate of flowers self-pollinated is 10848 and from these pollinations 910 fruits were matured which represent 8.39 per cent of the flowers pollinated. From the fruits matured there are now living 231 seedlings distributed in age from one to nine years; they were graded in October and appear in the records as 15 per cent "good", 26 per cent "fair" and 59 per cent "poor". Behavior of individuals in each of the three groups may be briefly considered.

ORCHARD VARIETIES

On the trees of the 30 orchard varieties, 1576 flowers were self-pollinated. Twenty-three varieties with 1119 pollinations failed to produce fruits. These varieties were:

Akin	Sops of Wine	Maiden Blush
Fameuse	Rhode Island Greening	Red June
Jonathan	Twenty Ounce	Domine
Oldenburg	Early Harvest	Isham
Willow	McIntosh	Lady
Osimoe	Winter Rambo	Winesap
Red Astrachan	Delicious	Grimes
Stayman Winesap	Ben Davis	

Seven varieties with 457 pollinations yielded 73 fruits as follows: Fanny 1, Longfield 49, Oliver 7, Rome Beauty 1, Tolman 1, Wythe 12, and Yellow Transparent 2. The two fruits from Fanny and Rome Beauty were seedless. Thus, five varieties bore 71 fruits; these contained 295 seeds, 180 of which germinated. The average of seeds to each fruit is 4.15 and 61 per cent of the seeds germinated.

Performance of self-fertilized varieties yielding seeds

Name	Year Selfed	Number Flowers	Number Fruits	Number Seeds	Seeds Germinated	Seedlings Living	Age	Grade Good	Grade Fair	Grade Poor
Tolman ...	1913	39	1	5	2	1	8	1	0	0
Wythe	1915	93	12	68	57	27	6	9	9	9
Longfield ..	1917	102	49	203	111	68	4	0	4	64
Oliver	1918	56	7	15	7	1	3	1	0	0
Yellow Transparent	1920	82	2	4	3	1	1	0	1	0

The net results are 98 living seedlings, eleven of which grade as good.

Crabs and Crab-Like Forms

On the 47 crab forms, 7863 flowers have been self-pollinated. Twenty-four forms with 2024 flowers failed entirely. These were:

Malus baccata (806)
Malus sylvestris (820)
Malus Niedwetzkayana (834)
Malus Malus var. (829)
Malus Soulardi (846)
Malus Toringo (853)
Malus crataegifolia
Malus Halliana (823)
Malus Prunifolia xanthocarpa (839)
M. Malus pendula (832)
M. Spectabilis var. (849)
Yellow Siberian Crab (857)
Malus baccata var. (808)
Malus sp? Fluke apple (822)
Malus prunifolia macrocarpa (837)
Malus Malus var. (830)
Malus Siberica (19643)
Malus Astrachanica (19670)
Malus angustifolia (1204)
Malus Cashmerica (1207)
Paradise stock
Malus Malus pendula (19688)
M. spectabilis var. (848)
Yellow Siberian Crab (a form)

Twenty-three forms with 5839 self-pollinations produced 784 fruits. Malus Toringo (851) produced 5 fruits, but they were all seedless. There were four complete failures in germination. These were Malus baccata oblonga (811) with 14 fruits and 1 seed; Malus coronaria with 3 fruits and 9 seeds; Malus Ioensis with 1 fruit and 2 seeds and Malus Toringo with 2 fruits and 2seeds. Each of three forms germinated one seed, but the seedlings soon died; these were M. Arnoldiana (802) which from 263 pollinations gave 6 fruits with 6 seeds; Malus atrosanguinea (804) which from 338 pollinations gave one fruit with one seed, and Malus floribunda which from 671 pollinations gave three fruits with three seeds. There remain 15 forms on which 3948 flowers were self-pollinated; these yielded 662 fruits containing 1952 seeds, 401 of which germinated. There are now living 109 seedlings, one to nine years old, and graded as 19 "good", 41 "fair" and 49 "poor". Performance of these 15 forms now represented by living seedlings appears in following tabulation:

Crab Forms Represented by Seedlings from Self-Pollinations

Name	Year Selfed	Number Flowers	Number Fruits	Number Seeds	Germinated	Sdlgs. Living	Age	Rating: Good	Rating: Fair	Rating: Poor
M. prunifolia var. (838)	1912	34	6	8	7	4	9	3	0	1
M. prunifolia var. (838)	1917	396	12	14	7	3	4	0	2	1
M. Toringo (19662)	1914	164	7	9	3	1	7	1	0	0
M. Malus var. (19667)	1915	33	22	75	17	1	6	0	1	0
M. Malus var. (19667)	1917	174	86	239	41	7	4	0	2	5
M. Malus var. (19667)	1919	120	58	191	44	7	2	0	2	5
M. baccata var. (807)	1917	170	52	105	30	3	4	0	2	1
M. baccata maxima (810) ..	1918	343	1	4	3	1	3	1	0	0
M. floribunda (821)	1917	671	3	1	1	1	4	0	1	0
Hyslop Crab (824)	1918	166	3	2	1	1	3	1	0	0
M. Malus fl. pl. (833)	1920	19	1	2	1	1	1	0	1	0
M. Sargenti	1920	120	30	43	2	1	1	0	0	1
M. punifolia (856)	1917	281	20	20	5	1	4	0	1	0
M. microcarpa (19644)	1919	212	31	71	50	39	2	10	11	18
M. prunifolia (19651)	1917	566	113	638	176	33	4	0	16	17
M. Toringo (19664)	1919	379	212	525	8	1	2	0	1	0
M. prun. var. (1208)	1919	88	3	4	4	3	3	2	1	0
Whitney Crab	1918	12	2	1	1	1	3	1	0	0
TOTALS		3948	662	1952	401	109		19	41	49

It thus appears that the 47 crab-forms, flowers of which were self-pollinated, 32 forms drop from the record either from failure to produce fruits, from seedless fruits, seeds that did not germinate, or seedlings that did not live; that for the 15 forms now represented by seedlings, only 17 per cent of the flowers self-pollinated matured fruits, the fruits averaged less that 3 seeds each, only 20½ per cent of the seeds germinated and only about 27 per cent of the seedlings survived; nearly half of them rated as poor and only 17 per cent rated good. Results are such as do not encourage sanguine hopes of easily securing a generation of selfed seedlings from this group of plants. There is, however, sufficient success to warrant continuance of the practice of pollinating crab flowers with their own pollen as often as the opportunity occurs.

Hybrid Seedlings

Having in mind the general tendency of hybrid seedlings towards sterility, self-pollination of such seedlings, and especially those resulting from the combination of widely different parents, was undertaken with the expectancy of a large proportion of failures. The expection has been realized, but there have been some unexpected results. It seems more probable that some degree of success should attend self-pollination of flowers of seedlings derived from the cross of two quite similar orchard varieties, than that success should result when the seedlings were progeny of crosses between orchard varieties and any of the small-fruited crabs,—for in the first case the parents are apparently quite alike,

while in the second case they are, to all appearances, very different. Yet, in every case, self-pollination of flowers of seedlings from crosses of orchard varieties failed, while such seedlings as have produced fruits following self-pollinations were those derived from crosses of orchard varieties and crab-forms.

Abundant material is now available and it is proposed to expand the work of self-pollinating hybrid seedlings, that needed information may be gained regarding degrees of fertility, or self-sterility.

Thus far 1409 flowers on 40 hybrid seedlings have been self-pollinated. Twenty-nine seedlings with 680 flowers failed to produce fruits. These with individual numbers, parentage and numbers of flowers, are as follows:

543-2-5	Domine	x	Yellow Transparent	10
505-1	Oldenburg	x	Yellow Transparent	2
730-2	Oldenburg	x	Hall's No. 6	2
1842-a-4	Rome Beauty	x	Winter Rambo	6
2946-4	Ben Davis	x	Summer Pound Royal	4
3173-5	Summer Pound Royal	x	Rome Beauty	6
(1)1261-a-2	Whitney	x	Yellow Siberian Crab	12
(3)1261-a-2	Whitney	x	Yellow Siberian Crab	14
1879-b-1	Tolman	x	Malus Toringo	63
1879-b-7	Tolman	x	Malus Toringo	37
1883-3	Tolman	x	Malus Toringo	23
2211-1-1	Whitney	x	Malus prunifolia (856)	43
2296-2	Ben Davis	x	Malus prunifolia (856)	16
2337-41	Malus prunifolia (838)	x	Ben Davis	14
2337-51	Malus prunifolia (838)	x	Ben Davis	3
2357-1-2	Yellow Siberian Crab	x	Rome Beauty	13
2161-1-2	Whitney	x	Winter Rambo	2
2386-3	Malus prunifolia (856)	x	Shackleford	12
2394-2	Malus prunifolia (856)	x	Shackleford	36
2397-1	Malus prunifolia (856)	x	Shackleford	12
2398-4	Malus prunifolia (856)	x	Shackleford	11
2612-5	Malus Arnoldiana	x	Winter Rambo	25
2669-6	Tolman	x	Malus floribunda	38
2671-4	Tolman	x	Malus atrosanguinea	109
2763-1-5	Roe Duchess	x	Malus prunifolia (856)	115
3001-1	Malus floribunda	x	Grimes Golden	10
8802-2-1	Jonathan	x	Malus atrosanguinea (804)	6
8803-1-1	Jonathan	x	Malus atrosanguinea (804)	33
2602-3	Malus Toringo sublobata	x	Rome Beauty	3

Total Number of Flowers 680

Eleven hybrid seedlings with 729 flowers bore 53 fruits. Two fruits, one from a seedling of the cross Yellow Siberian Crab X Rome Beauty, the other from a seedling of the cross Malus prunifolia (856) X Summer Pound Royal, were seedless. Seedling No. 2400-2, from the cross Malus prunifolia (856) X Shackleford, bore one fruit containing three seeds one seed germinated, but the seedling died in its second year; another seedling No. 2397-12, from the same cross, bore one fruit with one seed that did not germinate. Seedling No. 1879-b-6 from the cross Tolman X M. Toringo, on which 236 flowers were self-pollinated in 1921, yielded 7 fruits which contained 8 seeds. These seeds have just been planted and germination record will not be available until April.

Thus through failure to fruit, failure of seeds, or seedlings, 33 of the hybrids are eliminated from further consideration; the 34th has not progressed beyond the seed stage. There remain six that are represented by living seedlings. Details of performance of these six hybrid seedlings are given in tabular form:

Self Fertilization of Six Hybrid Apple Seedlings

Name and Parentage	Year	Flowers Selfed	Fruits	Seeds	Seeds germinated	Seedlings Living	Age	Rating: Good	Rating: Fair	Rating: Poor
2395-4 Malus prunifolia (856) x Shackleford	1918	57	3	3	3	1	3	0	0	1
2601-1 Malus Toringo sub. x Rome Beauty	1919	31	1	2	1	1	2	0	1	0
2842-2 Fameuse x Malus floribunda	1919	15	8	14	9	3	2	0	0	3
2842-2 Fameuse x Malus floribunda	1920	67	10	21	4	1	1	0	0	1
1910-1 Rome Beauty x Malus prunifolia (856)	1919	89	7	11	7	3	2	0	0	3
1910-1 Rome Beauty x Malus prunifolia (856)	1920	63	8	18	14	9	1	1	4	4
2921-1 Rome Beauty x Malus prunifolia (856)	1919	55	3	6	2	1	2	1	0	0
2329-35 Malus prunifolia x Domine	1918	10	2	10	9	5	3	3	1	1
		387	42	85	49	24		5	6	13

Considering only the six hybrids here tabulated, it appears that 10.85 per cent of the pollinations produced fruits; that each fruit contained 2.02 seeds, that 57.64 per cent of the seeds germinated; that 49 per cent of the seedlings are living, and that these seedlings grade as 21 per cent "good", 25 per cent "fair" and 54 per cent "poor".

Examining the three groups, and disregarding the disparity of numbers it is seen that orchard varieties produced more fruits in proportion to the number of pollinations than did either of the other groups; the percentage of success being 19.08; crabs come next with 16.76 per cent of the pollinations successful; and hybrids last with only 10.85 per cent successful.

In seed production, orchard varieties are even more distinctly in advance of the other groups. Fruits of this group averaged 4.15 seeds to each fruit, while the average for crab fruits is 2.94 seeds to each fruit, and for fruits from hybrids 2.02 seeds to each fruit.

In germination of seeds the orchard variety group leads with 61.01 per cent; hybrids come next with 57.64 per cent and then the crab group with only 20.54 per cent. The three groups take the same relative positions in regard to endurance of seedlings; 54.44 per cent of those from orchard varieties are living, 49 per cent of those from hybrids, and only 27.18 per cent of those from crabs.

Of course results of this work do not accrue until fruit production is established in the seedlings resulting from self- pollinations. How many of the 231 seedlings now living will endure to maturity cannot be predicted;it is expected that some will, and even if the number is small, there should be enough to compensate for the effort and encourage further similar work.

Factors which Influence the Production and Growth of Fruit Buds on the Apple

By T. J. MANEY AND H. H. PLAGGE, *Iowa State College, Ames, Iowa.*

The data relative to apples set forth in this paper are more suggestive than conclusive. They show in a general way how certain cultural practices and factors influence growth and how this growth affects the production of fruit buds and fruit.

For immediate consideration, reference is made to the behavior of Northwestern Greening and Jonathan trees growing on a uniform Missouri Loess soil, under four different systems of soil culture, viz., clover sod, clean cultivation with cover crop, clean tillage, and blue grass sod. The following table includes the figures on production and growth of these trees:

NORTHWESTERN GREENING

Plot	Number trees	Average annual Production per acre of 55 trees. 1912-21.	Circumference Increase. inches, 1910-1921	Average Twig growth per year inches 1909-21	Average weight per leaf grams, 1915-21
Clover	73	473.4	15.53	5.93	.79
Cover Crop	83	456.4	15.22	6.17	.76
Clean Cultivation	23	425.3	14.57	5.42	.74
Blue Grass	23	298.5	11.89	4.53	.68
		JONATHAN			
Clover	75	276.2		5.90	.69
Cover Crop	65	253.7		6.07	.67
Clean Cultivation	20	275.3		6.74	.69
Blue Grass	21	216.5		4.98	.58

The outstanding feature of this table is the evident correlation which exists between growth in its various forms and fruit production. The blue grass plot, when compared with the others, stands out prominently as an illustration of this point.

A critical examination of the trees on the blue grass plot, which have been consistently off year bearers, shows that the terminal growth, although it may have the length of the trees under the other cultural systems, is invariably devoid of leaves except for

a terminal whorl and the lateral buds are blind and permanently dormant. The lateral buds which form spurs do not break into fruit buds for years and the old spurs are very irregular in bearing. The opposite of this condition is true with the trees on the other plots.

The importance of these features cannot be overestimated as they furnish the practical grower with a visible indicator as to the nutritional condition of the tree. Quantitative analysis is of little value to the grower and in fact to the professional horticulturist unless it is coupled with a careful qualitative analysis of growth.

Production is dependent, first, on the maintenance of an available supply of fruit spurs, and second, on maintaining right conditions of nutrition and growth in these spurs and in the tree. The reduction of the number of bearing fruit spurs is larger than might be expected. In picking alone, it was found on the variety Eastman that with careful picking 40 per cent of the fruits picked carried fruit spurs with them. Patten Greening totalled 31 per cent, and Northwestern Greening 43 per cent. It is readily seen that this condition cannot go on indefinitely without lowering the production. The supply of fruit buds must be kept up by promoting strong terminal growth which carries live, lateral buds.

An example of the above condition is shown by a count of the total number of spurs on Jonathan trees grown under cover crop and blue grass sod culture. For this count trees 30 year old of equal size were selected; two from the cover crop plot and one from the blue grass plot. The two former trees gave counts of 15 900 and 15,800 spurs respectively and the tree on the blue grass plot, 12,631. The trees in question have been under the cultural conditions mentioned for 10 years. They had approximate diameter spreads of 22 feet and height of head above the crown of 15 feet. The condition of all the trees on the blue grass plot indicates a general lack of vigor as evidenced by scant foliage and deficiency of growth in fruit spurs and terminals. The number of fruit spurs which these trees carry is sufficient to produce a crop of 50 to 75 bushels, yet the records show that the average crop has been only 5 to 6 bushels. It is evident that only a comparatively small number of spurs blossoming and fruiting are necessary for full crop production. This data bears out Roberts' observations that the amount of fruit produced is inversely proportional to the amount of bloom carried.

Previous work of Roberts and Crow show that there is a pretty definite relation between the growth in the fruit spur and production. It has been found that fruit seldom sets on spurs which have made less than 5 mm. growth during the preceding non-bearing year. This evidence is strengthened when we note the data collected from Malinda trees, 18 years old, which carried a good crop during the season of 1921. Fruits numbering 4100 were picked from these trees, and the 1920 growth from which each fruit was picked, was measured. Only .35 per cent was produced on growth under 5 mm. Of the remainder 53.38 per cent was borne on 5 to 25 mm. growth, 27.30 per cent on 25 to 50 mm.,

and 18.96 per cent on 50 mm. and above. The longest growth recorded was 350 mm. In this particular instance it appears that growth below 5 mm. cannot be depended upon for fruit production.

A number of Roman Stem trees growing on clover sod cover crop and blue grass plots, were given applications of nitrate of soda three weeks before bloom, at the rate of 6 and 12 pounds. At the end of the growing season fruit spur measurements were made on these trees and on untreated checks. On the clover sod plot the check showed 68.3 per cent of the fruit spurs were above 5 mm.; 6 pounds of the nitrate of soda gave 84.5 per cent, and 12 pounds 91.1 per cent above 5 mm. On the clover crop plot the above order was 89:5, 77.8, and 96.1 per cent above 5mm. With the blue grass plot the percentages were 65.0, 81.9 and 76.0 above 5 mm.

Wealthy trees growing on a mixed clover sod were treated in the same manner with nitrate of soda and gave results as follows: check 90.4 per cent; 6 pounds 98.3 per cent, and 12 pounds 100 per cent of the spurs above 5 mm. growth.

In a general way these data show that nitrates do encourage growth in fruit spurs and vary the length of the spurs. If this growth does not influence production directly, it may do so indirectly by producing strong terminal growth which in turn furnishes an abundant supply of lateral spurs for subsequent fruit production. Fertilizer treatments in the past, especially those with cultivated orchards, may have failed because of lack of consideration of spur growth. Perhaps the growth was forced when it was not needed, or was not forced when it was needed.

Soil cultural treatments act very similar to nitrates in increasing and varying the length of fruit spurs. The following figures are indicative of the percentages of fruit spurs above 5 mm. in growth on Jonathan and Northwestern Greening trees, growing under different systems of culture.

Plot	Jonathan per cent	Northwestern Greening per cent
Clover Sod	82.4	79.1
Cover Crop	85.7	79.0
Clean Cultivation	87.7	85.5
Blue Grass	70.1	57.0

Comparing the above figures with those given in Table 1, it is clear that here again we have another indication of a correlation between growth and production.

At the present time there is a tendency to discredit the reliability of plot experiments. However, may not this be the result of failure to interpret the results from the standpoint of the different factors involved therein? These various factors including soil moisture, temperature, aeration, fertility, slope, climatic factors, variety, stock, hardiness, plant associations and many others, in addition to operations such as spraying, pruning, cultivating, harvesting, etc., working together, influence the quantitative and qualitative composition of the tree. It appears that any one of these factors when considered independently may be a limiting one in so far as production is concerned.

The Northwestern Greening before mentioned are planted in five rows, crossing the plots indicated from east to west. The trees are planted 28x28 feet and at the present age, 30 years, are beginning to crowd each other and thus restrict sunlight and root feeding area. A record was made of the production, terminal growth and circumference growth increase of the trees in the south row which has a good sunlight exposure as compared to the trees growing in the third row from the south which is heavily shaded by the adjoining trees. The following figures show the behavior of the trees in respect to sunlight and shade.

	Number of Trees	Average Total Production per tree in pounds 1912-1920	Average Total increase Circumference Growth per tree, inches. 1912-1920
Sunlight .	35	4483.2	16.22
Shade ...	46	2899.9	13.57

In addition to these data, measurements were made of the terminal growth on the south row of Northwestern Greening trees with respect to its location, on south or north side of the trees.

Plot	South Side Growth, inches 1917-1921	North Side Growth, inches 1917-1921
Clover sod	8.1	5.1
Cover crop	6.3	5.1
Clean tillage	6.6	6.1
Blue grass	3.8	4.0

It is appreciated that the factor of sunlight is not the only one involved. However, to one familiar with the conditions, it is apparent that it is one of the principal ones which has restricted growth and production.

The miscellaneous data given in this paper emphasize the importance of considering growth aside from composition as an adjunct in judging the effect of various factors on production. It is the only real indicator which the practical grower can use successfully in gauging the nutritional requirements of the tree.

The best nutritional practice is one which will encourage strong terminal growth, and thereby provide an abundant supply of fruit spurs. It may or may not be possible to vary the lengths of these spurs under all conditions. However, with good growth this is generally the case and fruit is produced, of course varying with variety, not only on old fruit spurs, but also on young lateral spurs and on terminals. These are the conditions on which annual bearing is dependent, and they are the result of innumerable factors working in harmony without and within the tree.

The Relation of Certain Orchard Practices to Fruit Bud Formation

By J. W. Crow and C. C. Eidt, *Agricultural College, Guelph, Canada.*

RECENT investigations suggest that fruit bud formation may be materially influenced in ways not previously recognized by certain common orchard practices, and that some of these practices may require to be considerably modified if best results are to be secured.

As a result of our studies into the biennial fruiting habit of certain apple varieties, we have come to the conclusion that the habit can be changed, and that alternate bearing trees can be induced to bear annually. We find that no practicable treatment can be given in the fruiting year which will materially affect the desired end, but have secured decided results by certain treatments in the "off" year. This is because in these trees fruit bud formation is confined entirely to the non-bearing year. Treatment during the bearing year may affect the size, or maturity, of the fruit during that season, but will have no effect on fruit bud formation the following season. Biennial bearing is caused by the development of too many fruit buds in a given year and corrective measures consist solely in preventing their formation in such large numbers. We find that trees of Oldenburg and Wealthy commonly produce blossoms on 80 to 90 per cent or more of their spurs in one year, while 30 to 40 per cent would be quite sufficient to produce a full crop of fruit. It is well known that individual spurs of the apple blossom every second year and that the bearing year of any desired spur or spurs can be changed by removing the flower buds in their unopened stage. This method would be entirely impracticable on a large scale and we are of the opinion that the only feasible means of accomplishing the purpose is to stimulate the growth of the tree in the spring of the off year so that a considerable number of spurs which would normally develop fruit buds are forced into vegetative growth and thereby prevented from doing so.

The most important finding we have to report in this connection is that the period of fruit bud determination is much earlier than we formerly thought. We find that disbudding to be effective must be done early—the earlier the better—and that the efficacy of the treatment diminishes daily until the tree is in full bloom. After that date we get practically no fruit buds and following the removal of the young fruit after it has set we get none whatever. We interpret these facts to mean that thinning of fruit has no effect on blossom bud development for the succeeding year and that normal fruit bud formation is controlled entirely by pre-blossom conditions. The number and vigor of the fruit buds which will bloom in 1922 was fully determined prior to the time of full bloom in 1921. Disbudding trials this season (1921) with Yellow Transparent and Wealthy verify the interesting results

secured on this point in 1920 with Oldenburg and Wealthy.

We find also that the spurs which form blossom buds in the non-bearing year range in lengths from 4 mm. to 12 mm. only. Spurs of three millimeters or less produce leaf buds or weak fruit buds. Growths of thirteen millimeters or over seldom produce fruit buds although we do occasionally find fruit on the end of a shoot several inches in length. The larger branches of the tree are of course usually terminated by non-fruiting shoots, which may be a foot or more in length and which have a growing season of two to four weeks or longer. In contrast to these we find that the spurs which are to develop blossom buds complete their growth in length in a remarkably short period of time and that they have finished growing by the time blooming trees of the same variety begin to drop their petals. The period of actual growth in length varies from four days to seven or eight days and is seldom longer. It will be obvious that treatment which aims at forcing any of these spurs into vegetative shoots will need to affect the spur before its growth has ceased, otherwise the result will be a full set of blossom buds, with no change in the fruiting habit. We have in our orchard mature trees of Wealthy which formerly bore only in alternate years, but which produced full crops in 1920 and 1921 and which are now well set with fruit buds for 1922. This result has been secured in two ways: first, by an application of sodium nitrate about the tree in the early spring of the off year; second, by a moderate heading back of small branches throughout the head of the tree, likewise in the spring of the off year. Both of these treatments have the effect, as stated above, of forcing into vegetative growth a certain number of spurs which normally would have produced fruit buds in that year. These vegetative shoots produce fruit buds in the following or bearing year, and we thus arrive at two sets of spurs on the same tree, each set acting independently and bearing fruit in alternate years. This is the condition we find actually to exist in annual bearing trees.

The importance of these observations as they relate to regularity of fruit bearing will be obvious, provided they are substantiated in actual practice, which we believe they will be. A full crop annually of high grade fruit should be the motto of every fruit grower who aims at maximum profits and who prides himself on his skill in the successful handling of his trees. The suggestions made herein require, however, to be considered from other angles, and it is not improbable that we shall find in them the key to other important orchard problems. If trees complete their growth as early in the season as has been stated, this fact becomes of the greatest importance and needs to be studied in relation to all of the conditions which have to do with the nutrition of the tree in early spring and in relation to orchard practices which may affect these conditions.

It has been pointed out that whether a given leaf spur is to develop a fruit bud or not, is largely a matter of the amount of growth it makes in length. By cross-sectioning spurs we find an even closer relation between fruit bud formation and spur diameter, those which produce blossom buds being stouter than those

which develop leaf buds only. In internal structure they differ also, fruiting spurs showing larger cells, with conducting vessels of considerably greater capacity. It would seem that the vigor of growth of spurs as evidenced in length, in diameter and in the size of cells and conducting vessels, is determined by the sum of all conditions which have to do with sap pressure at the time cell formation begins within the spur.

We find that a spur of small diameter produces fewer and smaller leaves and is invariably terminated by a leaf bud. We are inclined to the view that when once the physical structure of such a spur has been determined, it is not possible for it to develop a fruit bud. The amount of food materials and moisture which can reach the leaves, is limited by the small size of the conducting vessels, and the small area of leaf surface available for manufacturing will prevent the development of a fruit bud by restricting the amount of food necessary for the purpose.

These observations lead us to a consideration of sap pressure and the conditions contributing thereto at the time growth actually begins. These are:—

1. The quantity and nature of food materials stored in the tree.
2. The moisture of the soil.
3. The relative humidity of the atmosphere.
4. The temperature of the soil.
5. The temperature of the air.
6. The amount and intensity of sunlight.
7. The aeration of the soil.
8. The occurrence of winds.
9. The presence in the soil of soluble nitrates. Sap pressure at any given moment will be the result of all these conditions acting together, some in one direction, some in another, with most of them fluctuating from day to day or even from hour to hour. Under certain conditions any one of these may become critical and may materially affect the growth result. It seems to the writers that the problem of successful orchard management is the problem of regulating the growth of the tree and of manipulating the controllable growth conditions so as to secure the desired result. Mention has already been made of the method used in pruning for fruit bud formation and of the use of a nitrate fertilizer for the same purpose. Time and space are not available to discuss all the phases of this problem which are suggested by the list of nutritional conditions set forth above, but at least this much may be said: The important point is to make certain of a supply of moisture at the critical time which will be adequate for vigorous growth. Under ordinary conditions in our more or less humid climate, there is likely to be a sufficient amount, although in certain seasons, winter and early spring precipitation is notably deficient. The conditions which may reduce the water balance within the plant to a critical point are; lack of an adequate supply of moisture in the soil; a low soil temperature, making it difficult for the roots to take in moisture; high air tempera-

tures, bright sunshine, low humidity and drying winds, increasing the rate of loss from twigs, opening buds and young leaves; and lack of soil aeration, inhibiting root activity. So long as the roots are able to secure moisture in sufficient quantity the humidity, temperature and other conditions of the atmosphere are not likely to become important.

Dr. Russell of Rothamstead has shown how under certain conditions root growth may be prevented in early spring by the absence of a supply of oxygen, and points out how that a light rainfall may bring into the soil sufficient oxygen to produce growth out of all proportion to the actual amount of water involved. The amount of oxygen which may be brought to the roots by rainfall is not large, and is not, of course, subject to control, except in so far as we may provide drainage sufficient to secure the maximum absorption of rainfall into the soil and the least possible amount of run-off. In any case, we may state very definitely that thorough drainage for purposes of early spring soil aeration becomes a positive necessity.

So long as moisture is being taken in by the roots in sufficient quantity, the supply of soluble nitrates is likewise a matter of lesser importance, but if moisture is deficient artificial supplies of nitrate may go far toward overcoming the difficulty. Gardeners are quite familiar with the use of sodium nitrate to bring crops through dry weather, and as herein stated, we have secured marked results in vigor of growth from early spring applications of nitrate of soda. The extent to which stable manure applied in winter or early spring may become effective in bringing about the desired growth result becomes extremely important and demands investigation. The senior writer well remembers Mr. Elmer Lick of Oshawa, Ontario, recommending fifteen years ago the application of manure to apple trees in the early spring of the off year to bring about regularity of bearing.

Perhaps the most practical application of the suggestions made herein relates to the treatment of the the orchard soil. Clean cultivation with cover crops is in general the standard or orthodox recommendation, although the sod mulch with manure is giving remarkable results in many cases. Sod without manure, is, of course, pernicious and not to be considered. According to the Michigan investigations into soil temperature, sod thaws out at the same time in spring as bare or tilled land, but warms up quicker and for some few days is warmer than either. Tilled land is slower to become warm than sod or bare soil. It would appear also that sod land is likely to contain as much moisture for a short time after thawing as bare or tilled land, in which case it might reasonably be argued that roots under sod mulch would likely receive a better moisture supply because of the higher soil temperature and the more rapid rate of absorption by the root hairs. This idea is contrary to the view generally held and in the absence of direct evidence the suggestion is put forward for investigation. The sod mulch enjoys very decided advantage with regard to winter killing, and especially root killing, injuries of this character being notably less under sod than under tillage, so

long as the sod trees are not actually starved. The sod mulch system enjoys a very great advantage also in respect to color, although size of fruit ordinarily suffers. The writers are of the opinion that by proper attention to the growth conditions of early spring, it may be possible to secure in sod orchards quite as much vegetative growth as may be necessary or desirable for any purpose, and at the same time to avoid the winter killing which might reasonably be expected to follow the growth stimulation recommended herein. Clean cultivation with cover crops and manure as an orchard system is ordinarily supposed to possess advantages over the sod mulch system. The writers are in doubt as to whether any such advantage is actually inherent in the method, but can go no farther at present than to offer this analysis of the conditions affecting fruit bud formation. If we have done nothing more than to restate the problem in other terms, it may be that the clearer definition we have attempted will assist materially in bringing about the ultimate solution of this important orchard problem.

Extension Work in Fruit Fertilization in Michigan

By T. A. Farrand and Roy E. Marshall, *Agricultural College, East Lansing, Michigan*

No attempt is made in this report to give the history of fruit fertilization demonstrations in Michigan, except to state that the demonstrations are mostly of one and two years' standing.

The extension work in pomology is under the supervision of the senior writer as specialist for the Department of Horticulture and he is assisted by the county agricultural agents who are for the most part well informed regarding orchard practises. The extension specialist receives 25 per cent of his salary from the Experiment Station. This permits the specialist considerable latitude in planning his work. For instance, where a specialist is a full-time extension man, he is expected to devote his time to teaching or demonstrating practises which have already been sufficiently tested to warrant adoption by growers; but where arrangements are made for the specialist to be a part-time experiment station man, he is naturally expected to do some experimenting as well as extension teaching. With several of our orchard practises, but more particularly fruit fertilization, more or less testing and comparing of materials must still be done. This is especially true of a state with such diversified fruit interests and with such a wide range of soils as Michigan. Such a practise enables the Experiment Station to get results of numerous tests and on all kinds of soils; affords the extension specialist and county agents an excellent opportunity to show the farmers of the community what can be accomplished by the application of different kinds of fer-

tilizers; and perhaps, best of all, the extension specialist, having been in personal touch with such tests, is in a much better position to offer advice and takes more interest in telling about results "he" secured rather than those secured by some other member of the departmental staff.

In Michigan, the specialist in charge of fruit extension work is also secretary of the State Horticultural Society thus making his work much more effective. He is enabled to reach some parties that could not be "lined up" if such an arrangement were not in effect. Again, the objects and plans of the college and horticultural society become unified.

Fertilizers are usually furnished by the grower, but occasionally they are provided by the Experiment Station. The latter usually prevails in the more extensive tests. Under this cooperative arrangement between the experiment station and the extension division, either is possible. Most of the tests, or demonstration experiments, if you prefer such a name, have four plots, usually consisting of nitrogen alone; nitrogen and phosphorus; nitrogen, phosphorus and potash; and check. Most of the tests have more than four plots. In some of the tests, the treatments are in duplicate.

The tests are planned jointly by the specialist and county agent. Either one or both are present to supervise application of materials. In some cases the county agent is responsible for getting the results, but the specialist or his assistants collect the results of the more important, or more extensive tests.

During 1921 there were 31 demonstration-experiments with fertilizers on apples, 8 on cherries, 6 on grapes, 5 on pears, 4 on peaches, 2 on plums, 3 on strawberries, 3 on raspberries and one on blackberries, making a total of 64 such tests scattered throughout the commercial fruit producing sections of the state. These are exclusive of fertilizer experiments conducted by experiment station members of the department and those under the direction of county agents.

Space will not permit even a tabulation of results, but, as is usually the case, nitrogen has been the only element giving contrasting results when used singly with the several fruits. Phosphorus, as a supplement to nitrogen, has usually given better results than nitrogen alone and we feel safe in generally recommending a combination of these two elements. In several of the tests, the complete fertilizer has produced the best results, but these results are not consistent enough to warrant a recommendation of potash as a supplement to nitrogen, or to nitrogen and phosphorus.

Peaches have been the most susceptible to quick and pronounced results, while pears and grapes have been the least responsible to fertilization. Apples and cherries have both given immediate and contrasting response to fertilization. Bramble fruits have not given consistent results, but it is the opinion of growers of these fruits and grapes that fertilizers will prove profitable after two or three seasons of fertilization. Other departmental workers are having similar experiences with these fruits.

We feel certain that the arrangement we are now working under has several advantages over the full-time extension specialist plan and after one year's trial we are not convinced that there are any disadvantages of consequence.

West Virginia Demonstration Community Packing House, Second Report

By H. W. PRETTYMAN AND H. S. VANDERVORT, *West Virginia University, Morgantown, W. Va.*

The West Virginia Demonstration Apple Packing House has already proved to the growers by actual demonstration that the central packing house can handle satisfactorily a large apple crop either for an individual, or a community group. The best evidence of this fact comes from the dealers and consumers who purchased the "Johnny Appleseed Brand" put up by the packing house last year. Statements from these dealers show that they were well pleased and many expressed themselves as did one dealer in England who said, "The Johnny Appleseed Brand are the best apples we received this year." A further proof that this brand was properly put up is shown by the numerous unsolicited telegrams and letters received from dealers wanting this brand again this year. This proves that this packing house has demonstrated to the growers that a brand can be put up which will sell and stay sold and bring repeated orders, thus one of the objects of the demonstration packing house is being already realized.

The number of community groups who have come to the packing house this year to study its construction and operation, is further evidence that the growers are realizing that a packing house of this kind is becoming a necessity. Most of the vistors came with the intention of building a house of similar construction, either for their own use or for the use of the community. This manifest interest on the part of many of the progressive growers indicates that the extension division has demonstrated that the packing house is practical under West Virginia conditions, and will help to overcome some of the orchardist's difficulties.

The object of the state owned demonstration house is not only to show that such a plant is practical, but also to assist other communities and individuals to construct and operate their own plants. In order to carry out this part of the extension work, the superintendent has spent most of his time this year in showing interested groups and individuals over the plant, pointing out the method of construction, kind of equipment, and method of operation. In many cases the superintendent has gone to the different communities and assisted with the selection of site, and equipment, and worked out plans for construction. In some instances he has even assisted with the organization of the community group into a unit for the handling of the business connected with the operation

of their packing house. It is the purpose of the extension division to see that the fruit growers get the benefit of the demonstration house, even to the extent of carrying the information to every fruit growing community. It is gratifying to report that six packing houses are already under construction, or definite plans made, as a direct result of the demonstration house.

A large canning plant, which has been built this year by private interests near the demonstration house, is in position to take all the canning stock direct from the packing house without the necessity of loading into cars. This canning plant selected the location largely because of the packing house and the organization of fruit growers furnishing apples to the packing house. This year when so many of the apples were low grade, the canning plant proved to be a good outlet for the apples at fair prices.

The early freezes almost wiped out the fruit crop in West Virginia this year. As is always the case when there is a poor prospect, many growers failed to put on the usual number of sprays, and most of the apples in the section where the demonstration plant is located, where badly injured by insects and diseases. Good prices were offered for orchard run apples to be used by the cannery. In order to tell whether it would be more profitable to pack or let go at the good price offered by the cannery, a number of small lots representative of different crops were run through the packing house. The following is the result of two representative lots:

Lot 1. This was the entire crop from an orchard receiving the usual sprays.

237 barrels of York Imperial at $5.00 net	$1185.00
105 barrels of Ben Davis at $4.00 net	420.00
14,610 pounds of culls at $1.70 per hundred	348.33
Net returns on crop as sold	$1853.33
The same crop could have been sold as orchard run direct to the canning plant at $2.50 per hundredweight. On this basis it would have returned the grower approximately	$1550.37
Making a gain in favor of packing	$ 302.96

Which amount is equal to 49 cents per hundredweight on the entire crop.

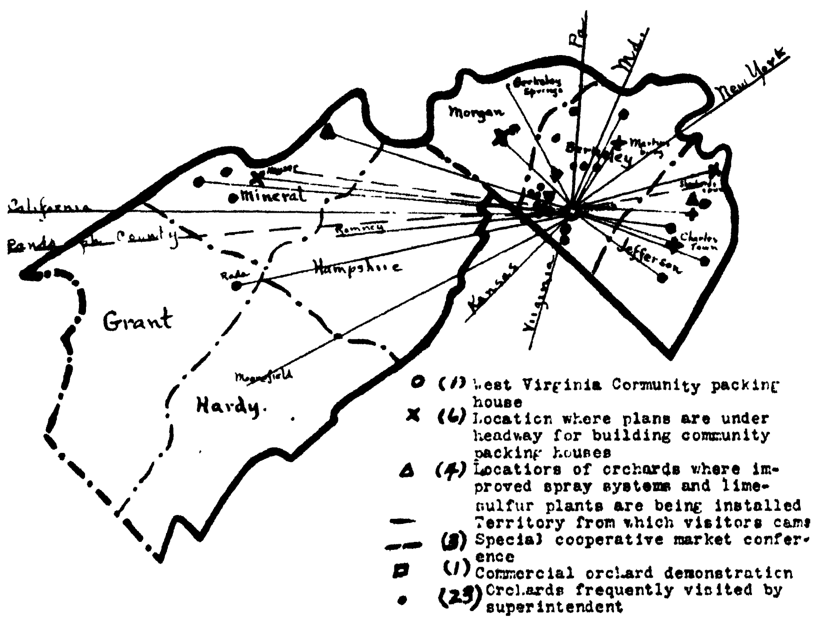
Lot 2. This was a small sample of what was considered average fruit which did not receive the proper number of sprays.

7 barrels of York Imperial at $5.00 net	$ 35.00
1865 pounds of culls at $1.70 per hundredweight	31.64
Net returns on the lot	$ 66.64
The same grade of fruit sold as orchard run to the cannery brought $2.50 per hundredweight or	$ 71.75
Making a loss on the sample of	$ 5.11

Which amount is equivalent to practically 20 cents per hundredweight in favor of selling to the cannery.

It is noted that the first lot from an orchard receiving the usual sprays graded so that 75 per cent was barrel stock while the second lot from an average crop this year graded only 34 per cent barrel fruit. The fact that the packing house was in position to determine for the growers by actual grading of a few small lots whether their apples should be graded and barreled, or go direct to the cannery this year, proved that the packing house is worth while even on an off year when there are few apples to pack.

The experience of last year which this year has been further emphasized in the minds of the growers, shows that there is need of technical advice close at hand and always available, especially during the spraying season. The growers feel that the packing house superintendent, who is in close touch with their business and who knows their local conditions, is the man who should give this advice and in a large measure exercise a certain amount of supervision over the spraying. This idea has been brought about largely because the growers are beginning to realize they must begin their packing and marketing of fruit by carrying out good orchard practice the year around. In order to supply this need the packing house superintendent next year will be the horticultural specialist for that section of the state in which the packing house is located. He will keep in close touch with the entomologists, plant pathologists, and others, and furnish any information valuable to growers and whenever necessary visit the orchard men and see that their orchard practice is such as to enable them to produce fruit which can be packed right.



The Value of a More Careful Selection of Plots and Longer Periods of Observation in Connection With Pomological Demonstrations

By J. OSKAMP, *Cornell University, Ithaca, N. Y.*

IT may not be out of place first to say a word in regard to how the extension work in pomology at Cornell Uuniversity is carried on, because of the bearing this may have on the brief suggestions that follow.

The work is done in co-operation with the country farm bureau. The demonstrations are staged at the request of the county agents who take care of local matters and furnish transportation within the counties. The greater part of these calls come from counties in which fruit growing is an important industry and where a large share of the farm income is derived from the sale of fruit. A decidedly small part of the extension specialists' time is devoted to the small or home orchard. The farm bureau manager is well able to look after the simpler home orchard problems and prefers to utilize the extension specialist in a way that will benefit the commercial production of his county.

The pomological work to be carried on in those counties that request it, is more or less permanently outlined each year at the county project committee meetings. At these meetings a committee representing the fruit growers meets with the county agent and extension specialist and they discuss the work to be undertaken. Here the growers who represent the leading thought in the county along their line of work have the opportunity to state what their needs are. The extension specialist has the opportunity of getting the viewpoint of the best growers in the county and he is able to advise just what his department has to offer. In this way a program more or less definite, but necessarily tentative is arranged for the year.

It might also be well to add, that disease and insect control is not a part of the subject matter of the Pomology Department.

I think most of those who are in position to judge will agree that fruit growers are as a rule a thoughtful and well read class of men. They probably come nearer to knowing the latest facts of science in connection with their business than most any other group of farmers. At least, before this society of horticulturists I can make such remarks without fear of contradiction. But what does this mean in a prominent fruit state like New York, where the leading interest in many counties is fruit growing. It simply means that in the really progressive fruit communities the ordinary annual demonstration has more or less lost its hold on the interest of these men. And it is largely because the difference between the practical information of the most progressive growers and that of the most scientific pomologist is today considerably smaller than it used to be. The superficial method and the "get by" attitude in extension must be discarded. Where fruit growing is a live issue then, and the extension spec-

ialist expects to keep a step ahead of the farmer, it is up to him to interpret to the grower the results of the latest experimental data. Probably the best way of doing this is by suitably chosen plots to be studied over a period of years.

The significant response of fruit trees to different cultural treatments may frequently be somewhat slower than for annual crops. It is probably of more value, even as a demonstration, to observe the response of the tree to the treatment than it is simply to observe how the treatment is given or applied. In fact, it is felt that the usual orchard demonstration falls short of what it could accomplish through the failure of providing the opportunity to observe the results of the work year after year.

Take for example the usual pruning demonstration. How many persons ever return to study the response of the tree to the pruning given. If they do not, it is doubtful if the demonstration has been as helpful as it might have been.

Indications are that a better method, at least in those counties where fruit growing is a prominent part of the farm enterprise, is to put more demonstrations on a five year basis. Then the people of the community can return each year and under the guidance of the extension specialist and the county agent carefully observe the progress being made by the trees in response to the treatment.

If such long time demonstrations are to have a sound and conservative development, more thought must be given to the laying out of demonstration plots than is ordinarily given. Uniformity of both soil and trees is desirable. The location chosen should be a representative area, so that the results may be typical of what can be expected when the practice is repeated on other farms, otherwise they might be misleading.

In connection with such long time work, permanent records, such as growth measurements and crop yields, would enhance the value and interest of the demonstration.

In some lines of work like pruning it is manifestly impossible to handle a larger number of mature trees. If a few trees are used it becomes important that their normal behavior be known before differential treatments start. In such cases crop records, if started two to four years in advance, will serve as an excellent criterion of the customary variation between the trees. This may seem a rather careful way to carry on a demonstration, but the point is we must interpret something worthwhile to the grower if we are to be of real service.

A few trees may be pruned at once without such preliminary study, but for the more permanent interest more careful work should be done.

Converting the Farm Orchardist

By F. R. Gifford, *University of Wisconsin, Madison, Wis.*

THE problem of the fruit extension specialist in Wisconsin can only be understood when the conditions under which fruit is grown in Wisconsin are known.

Wiconsin is a state of farm orchards. At least 75 per cent of the 3,150,000 trees in the state are in the farm orchards, a large per cent being in a neglected condition. Fully 75 per cent of the apples produced in the farm orchard are culls. During late summer and fall, Wisconsin markets are flooded with these culls taken in trade by the merchant to hold his customers. The consumer purchases this sort of fruit in small amounts for immediate consumption only and judges the apple crop of the state by those purchased.

The commercial grower finds it to his advantage to ship to a market demanding fine fruit rather than one flooded with culls. It is only to be expected that the consumer, being able to purchase only cull apples during the summer and fall, should wait for out of the state winter apples before purchasing a supply.

Our work then is only half done when we put our orchards into first class condition, and produce clean fruit. We must help educate the market and follow our fine fruit to the consumer.

In other words, we believe that the future development of commercial orcharding in Wisconsin depends to a considerable extent on what becomes of the farm orchard which is much larger than necessary to supply the needs of the home. It is questionable whether the best practice in commercial orcharding in Wisconsin is for the grower to have all his eggs in one basket. We think we have conclusively proved that many farmers with large orchards, and especially in communities where there are several such orchards, will find it profitable to provide the proper care for them. We believe that under this plan, they will not interfere as seriously with the market of the commercial orchardist as they do now with the inferior fruit which comes on the market from their neglected orchards. Some of these men who are now only farm orchardists will, with their new interest in fruit production, become commercial orchardists. In fact, cases of this kind might even now be cited. It is not at all improbable that commercial fruit growing in Wisconsin will be materially increased in this way.

The present conditions might at first glance seem to be very discouraging for the orchard specialist, but we of the Horticultural Department look into the future with optimism after seeing the progress made in counties where a definite intensive program has been carried on. To take a spray machine to an orchard and simply demonstrate spraying, or to prune a tree in a community arousing enthusiasm for the day, is not enough, at least, it is not enough for Winconsin orchardists. A definite workable program must be given orchard owners and help must be given until they are able to carry on the work themselves. They must have equipment and be able to use it.

We must leave a permanent work behind us or our time has been wasted and the money spent in vain.

Our program calls for intensive work in a county for a period of two years, as at least seven visits are made each year to carry on the necessary operations in the orchard but four counties can be worked, two of the first year work and two where work is in

progress for the second year. Each year two counties are finished and the next spring two more are taken on.

Work is always done in co-operation with the county agent. In addition to this, pruning demonstrations and whatever other help possible is given in those counties where work is desired, but in which intensive work is impossible because of insufficient personnel. Lectures are given during January and February to arouse interest in counties where intensive work is to be done and to meet demands from other counties and schools.

Pruning demonstrations are given during March and April with special attention to the four counties where intensive work is to be carried on. Here pruning is done in five or six communities and from these communities three or four are organized for the year's orchard work. Only enough work should be taken on the first year to permit of doing the work thoroughly and giving time to demonstrate to the county as a whole our operations. It is through thorough careful work in the few orchards, together with missionary work by the orchard owners, that we are able to practically cover the county the second year. In fact, so great has been the demand from every section of the county for second year work that it has been necessary to limit the work to 10 communities or spray rings.

Every man attending pruning demonstrations is expected to bring pruning tools and most of them do. Every man with an orchard is expected to prune. One-half day is given each community so that all the men wishing to do so may prune. The men are expected to go from the demonstration orchard to their own and put into practice what they have learned. In Jefferson County after five such demonstrations the men proceeded to prune 1500 trees, in Grant County 2,000 and so on. The success of our work in this line is somewhat due to the fact that we do not have large crowds to detract the attention of the interested ones.

Immediately after the demonstration we organize our spray rings. Five to twenty men make up the rings, depending on the size and type of machine. When a power sprayer is ordered, one man is chosen to operate it, but as each orchard is sprayed, the owner is expected to be on the job to learn the reason for each application.

In 1921, 180 orchards with a total of 11,000 trees were under supervision in the four counties. The 22 spray rings made supervision possible.

Every community is visited by the specialist each time spraying is done. In the spray rings a few trees in 2 or 3 orchards are sprayed by the specialist and then the operator take his turn, and when it is seen that he is doing thorough careful work, he is left to finish the job. Single orchard owners are started off in the same manner. A second year orchardist should be made to feel some responsibility, but he should be under the watchful eye of the specialist. A reminder over the phone or a postal card is often all that is necessary to get the desired results.

It is absolutely necessary to have the confidence of the farmers, if we are to expect them to be missionaries of better orchard

conditions and clean fruit. To get that confidence, it is important not only that we fulfill our promises to them, but that there be always evident a spirit of service and not just a mere business relation.

The results of orchard spraying should in some way be brought to the attention of merchants and consumers as well as growers who do not spray. To do this, demonstration exhibits were put on in counties where intensive work was carried on. Exhibits this year demonstrated to growers the value of spraying and grading fruit, to the merchant the value of buying and selling sprayed and graded fruit, and to the consumer the relative value of sprayed and graded fruit and unsprayed fruit.

A new type of work was started this year. As has been said, marketing is as important an operation as spraying, but has received little attention heretofore. The new work carried on this year was in assisting the orchardists who sprayed to dispose of their fruit. It is an interesting fact that the orchardist who has never had enough fruit to supply his own needs becomes greatly concerned about possible inability of being able to dispose of his surplus. Strange as it may seem this is the reason given by many farmers for not taking proper care of their orchards. This arose in connection with the spraying work carried on in the three spray rings in Jefferson County.

Some of the growers had tried to market their fruit without success and it began to look as though much of the good effects of producing a crop of good fruit might be lost. It was found upon questioning some of the men that several of them had tried to sell the fruit orchard run, even putting in the windfalls. A meeting of the interested growers was called, and a plan of co-operative grading and marketing was formulated. The plan was based upon the principle that all parties should profit by such an organization.

The first move was up to the grower. He was made to see that although his fruit had been sprayed, it was still necessary to grade and market attractively in order to get the best results and create a demand for high grade sprayed fruit.

After a considerable argument four retailers were persuaded that the growers were offering them an opportunity to make more money on apples than they had been making handling the general run of cull stuff brought in by the farmer who did not spray and grade. The agreement reached with the retailer was that he was to pay the grower a fair price and that he was to sell the fruit at a reasonable profit agreed upon by the grower and retailer. In order to get the plan started it was necessary for the grower to agree to take back all fruit not sold within a definite period.

The final problem was to interest the consumer. This was accomplished, not by putting the usual one or two baskets of fruit in an out of the way place in the store, but by using the display window for advertising Wisconsin apples as it was used to display other goods. The show window was filled with an attractive display of sprayed and graded apples and on the window was printed: "Special Wisconsin Sprayed and Graded Apples.

Hand, Picked, Graded, No Worms". Inside the store in a conspicuous place were other baskets of the same fine fruit. The window display immediately attracted attention and resulted in many customers. We asked the merchant when taking orders over the phone to mention the fine fruit on hand. The grocer who made the first trial said at the close of the first day's business that his sales of apples that day had exceeded his entire sales of the week previous. While he had not made so much profit per pound as on the inferior fruit, his total net profit was much greater. Two days later the grocer asked for a second consignment, and thus the sales went on until the apples were gone. The seemingly impossible had been accomplished. The producer had found a profitable market almost at his door. The grocer was reaping larger profits and the consumer, the best satisfied person of the three, had learned that good Wisconsin apples were to be had at a price which made it poor economy to use an inferior grade of fruit or to insist on imported apples at much higher prices.

The problem of the grower was no longer to find a market. It had become one of keeping his market supplied with the grade of fruit which made possible his market. Co-operation was necessary to do this. The farmer picked and graded his fruit as it became ripe. One of the spray machine operators, where possible, was made sales manager and inspector. The sales manager received the orders and when he found the fruit O. K. consigned it.

The result of this venture was that the growers disposed of all the fruit from their 1200 trees at remunerative prices, the grocers were convinced that it is not necessary to handle the cull fruit usually offered by the farmer and that they did not lose but rather gained customers; and the consumer learned that he can have good fruit if he demands it at a price which is not prohibitive.

As a result of the work done in 1920-21, 35 communities have asked for organized spraying with power sprayers. The whole state seems to be applying for orchard help. Eighteen counties have recently applied for orchard work. With only one man in the field, the state will not be covered rapidly, but where intensive work has been done following the definite program, fruit-growing has taken a decided jump in the right direction.

Effect of Time of Application of Nitrogenous Fertilizers on Tree Growth, Bloom and Fruit Production

By G. S. RALSTON, *Experiment Station, Blacksburg, Va.*

THE use of nitrogenous fertilizers has become rather general in commercial fruit growing districts. It is true that the comparative merits of cultivation, the use of nitrogenous fertilizers, and the practice of certain types of pruning treatment—all

of which lend vigor to the tree or to the parts that remain following pruning treatment—are debated pro and con, but at the same time the use of quickly available nitrogenous fertilizers, singly or in combination with other treatments, is generally approved in connection with retarded tree growth and light production.

Nitrogenous fertilizers were formerly applied about blooming time with the expectation of increasing fruit production the succeeding season, but without thought of materially modifying the yield in the season of treatment. Investigations in Oregon and elsewhere indicated that the crop could be materially increased during the season of initial treatment, providing application was made some time in advance of the bloom season.

During the years 1914 and 1915, a few instances came to light in Virginia in connection with the influence of early application of nitrogenous fertilizers in apple orchards. Through mistake nitrate of soda was applied in late February. While no authentic record of yields and growth conditions was secured, it was learned that the results were very promising and the theory that the nitrogen in nitrate of soda was lost if not almost immediately utilized by the tree was negated. At the same time there was reason to believe that the current season's crop had not been materially increased.

All this led to speculation concerning the effects of treating apple trees with nitrogenous fertilizer at different times during the growing season. The thought dealt with modification of fruit production and growth habits of the tree during the season of initial treatment and during subsequent years' treatment. The effects on tree growth were thought to be of value as the means of indicating externally the possibility of fruit production.

Investigations along these lines were initiated during the spring of 1918 as a minor project—the qualifying word minor here indicating that only a comparative small amount of time could be devoted to the project. Trees of weak vigor were selected for the test. As originally planned, nitrate of soda in medium amounts was applied on comparison plats, treatment beginning with March 1st and continuing at monthly intervals until August 1st. The investigation with certain modifications has continued up to the present time. All the vicissitudes incident to co-operative projects have occurred and in addition cedar rust and frost injury, in what theretofore were said to be frost free situations, have caused irrepparable injury. In spite of all this it is possible that certain tentative conclusions and certain discussions are worthy of presentation.

Since this paper is presented on the extension program, all tabulations will be omitted and the several factors of which records have been made will be briefly discussed. It should be understood that this report is preliminary in anture and refers practicularly to treatment of trees of relatively low vigor.

Effects of time of Application of Nitrogenous Fertilizers (Nitrate of Soda) on Shoot Growth:—The use of nitrate of soda soon after growth is resumed in the spring, particularly applications given the 1st of March, the 1st of April and the 1st of May, are much more conductive than later treatments to total amount,

length and diameter of shoot development. Later treatments increased the size of actively growing shoots, but the effect became less marked as time of application was retarded. The earlier the treatment after the resumption of growth in the spring, the more uniform the growth throughout the tree. The same conditions have held true during subsequent season's treatments although the differences are not so marked, even though very striking, after several years treatment.

Effect of Size and Color of Leaves. Both the size and color of the leaves had been enhanced to a very marked extent by early applications, and the earlier the treatment after the buds commenced to swell noticeably the greater the response. At the same time treatments made in early April and early May have been very beneficial in this respect. Foliage developing in late season was increased in size by late treatment and color of the leaves was deepened by all treatments, even though elongation of the shoots and spurs did not occur in the latter treatments. The color of the leaves was not so intense on the trees receiving later treatment. Apparently, the nitrogen was utilized to some extent by the trees receiving late treatment, even though no further elongation of shoots and spurs took place. Both size and color of the leaves were greater under early treatment, the effects decreasing as time of treatment was delayed.

Effects of Spur Growth. The effects of time of application on spur growth has been quite marked. Many measurements made indicate that length of spurs on rather weak trees has been materially increased by early treatment the season of initial application, but that the effect rapidly becomes less as time of treatment was delayed. However, treatments made as late as June apparently have caused some very slight difference in spur length. The early treatment also had a tendency to promote uniform development of spur growth throughout the tree, the uniformity of development lessening as time of treatment was delayed.

Continued treatments in subsequent years have tended to increase the growth of spurs greatly, the earlier treatments having induced more uniform and longer growth. Many spurs have been forced into active growth, particularly on trees receiving early treatment and to a lesser extent on trees receiving later treatment. Many short stocky shoots have borne terminal and axillary buds. Such shoots, largely from 5 to 8 inches long, are commonly developed from spurs following the second and third season's treatment. This same character of growth has been noticed the past summer on trees that were badly broken by the ice storm of 1920.

The number of spurs per linear unit has tended to decrease under successive treatments, more particularly under early applications, and such treatment might be carried to the point that production would be lessened. However, in general in the orchards under observation new spurs formed on the new wood and old ones strengthened so that the total number borne by the tree has not been decreased to the detriment of fruit production. The spacing of the spurs has become better and they seem to function to better advantage.

It has been observed that the diameter of the spur is apparently intimately related to fruit bud formation and fruit set. This relationship has not been measured in any way in this work, but it shall be considered in subsequent records.

Effects of Time of Maturity. Time of application, especially during the season of initial application, has had but little influence on time of absolute maturity of shoots and spurs. It appeared that development took place more rapidly and ceased slightly earlier on trees receiving treatment in early March and to a lesser extent on trees treated in early April. Perhaps the larger size of the spurs and buds on the early treated trees was accountable for the appearance of earlier development.

It appears that like parts—that is parts that are alike in type of growth and size--tend to mature at approximately the same season, regardless of whether they are on the same or on different trees. The more vigorous trees contain a greater amount of the stronger growing parts so they appear much more active at certain seasons in so far as growth enlongation is concerned when compared to weaker trees. This has occurred in the comparison of early and late treated trees since the stronger growth is found in greater amounts on early treated trees. However, complete cessation of elongation seems to stop at approximately the same season on all plats in-so-far as it is affected by time of treatment with nitrate of soda.

Moisture seems to have a great influence in regulating duration of growth and the availability of plant food largely governs the rapidity of growth.

Effects of Bloom. Bloom has been materially increased on all treated trees the year after the initial treatment was given with the exception of one very weak orchard that did not bloom at all following a very heavy bloom and medium heavy crop production the year of initial treatment. The amount of bloom has been somewhat greater on the trees receiving early treatment, but the difference between plats has not been so marked as in the case of wood growth. Apparently nitrogen stored from the previous year has a great influence on bloom, many buds bloom following late season treatment that otherwise would not function. There has been apparently little increase of bloom the season of initial treatment due to treatment in very early spring.

The bloom decreased to a marked extent the year following the second treatment on all plats except those in previously mentioned very weak orchard. In succeeding years variations have occured so that trees receiving late treatment at times have carried the greatest amount of bloom, although to date trees in earlier treated plats have produced greatest bloom total. However, the smaller percentage of bloom borne by the stronger growing trees in later years apparently set a larger percentage of fruit so that within reasonable limits too much value should not be placed on bloom data alone.

Effects of Fruit Production. The fruit yield as modified by time of treatment, has not been so conclusive as might be wished, due to various factors apart from the one under investigation. At the same time the yield has been increased slightly during

the season of initial application in all plats receiving the earliest treatments. Lesser increase followed the April treatment. The increase due to earliest treatment is not very marked in any case and were it not for the fact that it has occurred in every orchard under observation it would not be considered very significant. Perhaps if the production had been heavier the effect during the current season of application might have been more marked. It is possible that the margin wherein the crop can be materially increased during the season of initial treatment is not so general as might be thought on account of marked results in a number of instances. At the same time the tendency seems to be towards increased production the season of initial treatment, provided the application is made early enough in the spring. Further records are necessary before a reason can be given for the increase in current season's production. Such records should include study of fruit set, fruit drop and careful estimate of increase in size of fruit. It seems that the size of fruit has been increased to some extent by the use of nitrate of soda, particularly by early treatments on trees of very low vigor.

Trees receiving treatment after the 1st of April were benefitted to some extent in-so-far as production was concerned, the effect decreasing very rapidly as time of treatment was delayed.

The early treatments have marked effect on size of subsequent crops, the earlier treatments in all cases being more conducive of larger production during the four years duration of investigation. It is conceivable that this condition might change as tree vigor became stronger, although it has not been manifested as yet in the orchards under observation.

General Conclusions

Nitrogen regardless of time of application apparently does not induce resumption of tree growth, but it strengthens actively growing parts to a marked extent, consequently the earlier the treatment after growth activity is resumed in the spring, the more uniform and the greater the growth reaction.

Nitrogen may be taken up and utilized to some extent by the various parts of the tree after elongation has ceased, thus giving them greater functioning ability the succeeding season. However, this response is much less than that under earlier treatments which were accompanied by increased length and diameter of vegetative parts.

Time of application of quickly available nitrogenous fertilizers has a marked effect on tree growth, and within more restricted bounds on fruit production during the season of initial treatment. Apparently, the amount of bloom is not greatly influenced by early applications during the initial season of treatment in the orchards under observation.

Treatments given after the sap flow becomes active, but before the buds begin to open (when buds are swelling) greatly and uniformly strengthen growth of vegetative parts, including both shoots and spurs. Treatments later in the season give relatively less growth response, especially in relation to number of growing

points that elongate into shoots, the size of shoots, and to the increase in size of spurs.

Apparently bloom is more readily modified by time of treatment than fruit set since midsummer treatment increased bloom materially the season succeeding treatment; in fact, almost as much as under earlier treatment, but the fruit production was influenced to a much lesser extent than under the early treatment. It is possible that under conditions of stronger tree vigor than was under observation, results as to bloom and fruit production might be modified adversely from that herein mentioned.

Time of maturity, or rather time when elongation of vegetative parts cease, has not been materially modified by time of application. Apparently, duration of growth is greatly influenced by moisture conditions and rate of growth by availability of plant foods.

Fruit production has been increased slightly the season of initial treatment and increased materially in succeeding years, the response becoming less as time of application was retarded. Apparently size of fruit may be increased to an appreciable extent by early treatment, especially in connection with trees of low vegetative vigor.

The comparative range of influence on growth and fruit production as affected by time of application has been relatively constant over a period of years of continued treatment in the orchards under discussion.

Treatments should be given according to growth development of the trees rather than according to the calendar. When the buds commence to swell in the springtime seems to approximate the time of treatment that is conducive to best results in the case of trees deficient in nitrogenous plant food.

One Season's Dusting Against Cucumber Beetles and Anthracnose of Watermelons in Missouri

By H. A. Cardinell, *University of Missouri, Columbia, Mo.*

At the beginning of the 1921 season the Southeast Missouri Melon Growers Association asked the Agricultural Extension Service to demonstrate a practical control measure for the striped and spotted cucumber beetles. As a result, Mr. E. M. Page, Extension Specialist in truck and vegetable crops, and I, devoted most of the season to their needs.

Chittenden states that arsenate of lead has proved the most effective against the striped cucumber beetle (Diabrottica vittata), and that a spray of one and one-half pounds dry arsenate of lead to fifty gallons of water has proved as successful as when six pounds were used. In the same publication he recommends that three pounds of the dry form be used in conjunction with soap

and bordeaux. Reed states that no successful method has been found to control this pest on a large scale, but that four ounces of turpentine or crude carbolic acid mixed with a peck of lime or ashes, will be very effective when sifted over the hill to repel the beetles. Essig states that poison sprays aid in controlling the beetles and that repellants of land plaster soaked in turpentine or kerosene will tend to keep away the beetles. Essig again states that arsenate of lead at the rate of six to ten pounds to 100 gallons of bordeaux mixture, or the same amount of water, have each given good results. Garman gives one and one-half pounds of powdered arsenate of lead to 50 gallons of water as the right proportion, while Brown prefers two pounds of the powdered form to 50 gallons of water.

Thus we have a vast array of recommendations facing the grower with no guarantee of success if he tries all of them. It was necessary to look for newer materials, or combinations, that would give as good or better results than have been obtained in the past by liquid or dust control methods.

Fortunately Campbell published the results with volatile nicotine sulphate dust against these beetles and we were able by express shipments to obtain a few hundred pounds of "Nico-dust" from the Walnut Growers Spray Manufacturing Company, Los Angeles, California. However, this material, which will be mentioned later, was out of the question for this year's use by the commercial growers, due to transportation rates. After conferring with the department of horticulture, it was decided to try a mixture of one pound arsente of lead powder, one-half pound paris green and 15 pounds hydrated or air slaked lime on the earliest patch in the melon territory, which was at Kennett, Missouri.

This mixture applied as a dust in a hand-operated bellows type duster gave such complete control based on the amount of feeding injuries in a four acre field as compared with adjacent fields untreated, or treated with liquid sprays, that it was decided to give wide spread publicity to this formula.

Over 90 per cent of the growers of watermelons and cantaloupes used this dusting mixture and though most of it was applied in the crudest manner, using perforated cans or cheese cloth bags fastened to sticks as handles, there was not a report that did not praise the control and there was less reseeding, due to the ravages of the beetles, than has taken place for many years. Furthermore, this was in spite of the fact that the melon growers, as well as the Department of Entomology of the University, state that this has been the worst beetle year since 1916.

There were only three power liquid sprayers in the entire territory and while they attempted to control the beetles with two to three pounds of arsenate of lead powder to 50 gallons of water. they soon gave it up in disgust, because their neighbors using the dust formula were able to get better control at one-tenth the cost. As was expressed by the owner of a new liquid power sprayer, it was necessary to go over his large field with the dust formula the day after the liquid application was made, in order to save the

seedlings from being destroyed in the entire field. He stated that he counted an average of 20 beetles per hill.

Mr. Page and I were able to make observations on several fields of watermelons and cantaloupes where nicotine sulphate dust was used throughout the period of severe beetle attack. Only the 10 per cent strength of 40 per cent nicotine sulphate dust was used. The control was very effective while the sun was shining and when too much wind was not blowing, but strictly calm days were not selected at the expense of injury to the plants. Many times during this spring and early summer, it was necessary to make applications of Nico Dust on warm days when a strong breeze was blowing spasmodically because the beetles were mowing down the younger plants, especially in replanted hills. Howard states that nicotine sulphate dust dissipates its strength in about three hours, but we found that it was necessary to strike the beetles with the dust in order to kill them, and those that flew to the hill immediately after the dust was applied, were not killed regardless of the amount of fresh Nico Dust lying on the ground and leaves. Beetles that alighted in this dust only showed some signs of discomfort such as might have been noticed had they walked over lime dust and they often refused to take flight, but would crawl over the plant in search of food. Apparently the killing power of this brand of nicotine sulphate dust lasts only one or two seconds under average field conditions, and is undoubtedly less when a slight puff of wind comes up as was observed by dusting plants through screen cones and immediately throwing a handful of striped cucumber beetles under the cone. Dr. L. Haseman of this station states that he noted similar results in the use of this material in his investigations this season on the station grounds.

Nico Dust seems to have a three day repelling action during which time not even ants were noticed near the dusted hills in several acres, but on the fourth day insect feeding began.

After noting the short killing time of Nico Dust on a four acre field of watermelons at Kennett, Missouri, I decided that if this dust was to become practical, considering its cost, a longer killing period was necessary. Ten pound lots of Nico Dust were mixed with "Lazal", calcium arsenate, and arsenate of lead and applied to separate blocks of rows and the result was gratifying in that the period of control was lengthened several days. The only difficulty came from the crude method of mixing the poison with the Nico Dust, for much of the strength of the nicotine sulphate was lost before a thorough mixing could be made.

If kaolin ties up more nicotine than does lime, as suggested by Morrill, perhaps the mixture he suggests of the required amount of nicotine sulphate mixed with about 90 per cent lime and 8 to 9 per cent sulphur has some promise. Sulphur alone as a carrier for nicotine sulphate has the disadvantage of lacking sticking properties.

There is apparently a lack of standard terms denoting the strengths of nicotine compounds manufactured by different firms. Eustace states that Niagara Contact Dusting Mixture consisting of sulphur 49 per cent, nicotine 0.25 per cent, inert ingredient

50.75 per cent, controlled aphids on cucumbers and squashes. It is often difficult to determine from labels or reports whether the nicotine is expressed in terms of pure nicotine or pure nicotine sulphate. Morrill claims that the melon aphis requires a 1.6 per cent strength of pure nicotine (or its equivalent 3.2 per cent pure nicotine sulphate of the 40 per cent strength) so that it would seem that Eustace using only 0.25 per cent nicotine had the benefit of the additional killing power of the 49 per cent of sulphur or that the sulphur liberating more of the volatile nicotine was able to obtain the same killing power as other workers have reported using nicotine sulphate in a carrier of kaolin or lime. Moore and Graham have thrown some light on this subject. They state, "The more nearly the atmosphere is saturated with the vapor, the more liklihood there is of a condensation in the trachae. The other force is the tendency of the compound to re-evaporate from the tracheal walls. In the least volatile this tendency to re-evaporate is generally diminished, while in more volitile compounds, in order to reduce this tendency to re-evaporate, very large quantities of the chemical must be present in the air." This was noted in the mechanical process of applying Nico Dust. In dusting plants three of four weeks old one stroke of the duster expelled enough Nico Dust to kill the beetles exposed on the outer part of the plants, but beetles beneath clods or feeding in the denser parts of the foliage were only disturbed, and by the time they took flight the dust remaining in the air was too weak to stop them as they flew through it. We, therefore, adopted the practice of making two strokes to each hill, the second stroke of the duster usually caught most of the beetles that were disturbed into flight as a result of the first stroke.

Calcium Arsenate and Gypsum

This material was used as recommended by Ohio at the rate of one part of calcium arsenate to 20 parts of land plaster. They stated that this mixture was found to be superior to 25 different materials and combinations that were tested against the striped cucumber beetle and recommended that ten to twelve applications are usually required at the rate of two a week and more often if rain occurs.

This strength was tried throughout the beetle season at Kennett, Missouri, on a field owned by Dr. Paul Baldwin where all the other materials were tested. It proved to be equal to the arsenate of lead—Paris green—lime mixture, as used over the district, in preventing feeding injury, but it did not seem to have as quick killing properties as did the latter. It gave severe burning throughout the season when used in the best type of duster available. It has an added disadvantage in that it is so heavy and fine that it settles to the bottom of the duster and too large quantities are forced out at each stroke of the dusting mechanism and a given quantity will only go about one-third as far as other materials used. Calcium and gypsum applied at the same dates did not compare in effectiveness with 9 9 per cent Nico Dust applied every four to six days, and was not as good as Nico Dust of

that strength to which has been mixed five per cent of arsenate of lead, although the later was applied only every seven to ten days.

Copper Dusts for Watermelons

The extension service has been called upon for help in the control of anthracnose on watermelons for the past three seasons and we have attempted to demonstrate the value of bordeaux liquid sprays, but only failure has resulted, due to the fact that only one barrel sprayer could be found in that section and since the growers would not leave roadways through the fields only two applications have ever been made.

This season two traction power sprayers and one engine power sprayer were available, but again the growers in these spray rings failed to follow our advice and no roadways were left so only two applications were made and the disease was not controlled.

Knowing their opposition to "wasting" roadways, it occurred to me that if dry copper dusts would control anthracnose, they would be universally adopted since they could be cheaply applied with hand dusters as used for insect control.

The dry bordeaux used in these trials was the equivalent of 21.82 per cent metallic copper. Therefore, it was used at the rate of one pound dry bordeaux to one and one-half pounds hydrated lime.

The time of applications were the same as recommended by Meier as shown in the following discussion.

There were 150 rows of watermelons in the Baldwin field set 10 x 10 feet with 32 plants to the row, growing on one of our best watermelon soils, Lintonia fine sandy loam. Due to drought in May the splendid growth of plants was checked later in the season and died before half of the melons were mature as did most plants in the entire territory, therefore, yield records were not obtained on the dusted plots.

Dehydrated Copper Sulphate

Rows one to eight, inclusive, were the only ones receiving dehydrated copper sulphate one pound to four pounds of hydrated lime. Two applications were made, one on June 26 and one on July 21. The second regular application was omitted due to the fact that the pathologist could find no anthracnose lesions on the leaves sent in for examination, and no further applications were made. An average count for two pickings showed 12 melons for the eight rows having an average of one "blister" per melon.

Rows 21 to 29 were used as checks against the dehydrated plots and the average of the two pickings was 24 melons per row too badly diseased to make lesion counts.

It is difficult to understand why the materials used on rows one to eight gave better results than the dry bordeaux applied on the same forenoon by the same man and machine. It is possible that the dehydrated copper sulphate, being manufactured for dusting purposes, stuck better to the surfaces than did dry bordeaux which was not made for dusting purposes. However, a

better explanation may be found in the fact that the first application of dehydrated copper sulphate was very heavy, 9 pounds to each row to test burning probabilities.

Dry Bordeaux Mixture

Rows 9 and 10 received four applications of dry bordeaux and lime at the rate of one pound to one and one-half pounds of lime for all applications. An average of the only two pickings made was 14 melons which showed one to three small lesions.

Rows twelve to fifteen, inclusive, had 4 applications of dry bordeaux and lime. The first application was stronger than the remaining applications using one pound bordeaux to one pound of lime. The last three applications were one to one and one-half. Every melon was thoroughly examined and an average of two pickings showed nine mellons per row with three to five lesions per melon.

Rows 16 to 20, inclusive, had two applications, the regular second application being omitted. The average of two pickings was 21 melons per row too badly infected to make a count of the blisters.

Rows 30 to 41, inclusive, were used as checks against the bordeaux plots, and the average of the two pickings was 20 melons per row too badly infected to make lesion counts.

These trials with copper dusts did not give as good control as has been obtained in other states when four to nine applications of liquid bordeaux mixture have been made, but this one season's trial showed that as good control might be expected had more applications been made. Under Missouri conditions where the growers will rarely purchase high power liquid sprayers and can not be relied upon to leave roadways for late applications, dusting with copper dusts should give fewer diseased melons than if no treatment is given, and due to the cheapness of applying dust, it should appeal to our melon growers.

Sticking Properties of Copper Dusts

There is more copper placed on the under surface of the leaves with a bellows type duster than we have ever been able to get using 300 pounds pressure and six foot extension rods with two angle disc nozzles per rod on liquid machines.

Soon after the first application of dust was made two heavy rains fell and I expected that all the material had been washed from the plants and that an application would be necessary after each rain.

In order to throw some light on this question, one plant (plants one-third grown) was pulled from the plot that had had a regular application followed by an all night rain and was dusted the next morning, but a three hour rain fell in the afternoon of the second application and very little sign of the bordeaux could be seen. This plant which had received a hard rain following two applications on two consecutive days was sent to the department of agricultural chemistry for copper determinations. Likewise one

plant from the plot which had had the first application of dust followed by the two rains mentioned above was sent in for copper determination. Mr. C. R. Moulton, chief chemist, states in a letter of June 25th, "I have finished the determination of copper in the watermelon plants. The Baldwin (field) plant from rows nine to ten contains 23 milligrams of copper. The plant from rows eleven and twelve contains 20 milligrams. I have calculated this in terms of bordeaux spray containing one pound of blue vitriol for ten gallons of water. In terms of this solution the above amounts of copper are equal to 7.5 c. c. and 6.7 c. c respectively". It is difficult to determine whether or not that amount of copper would give any protection against disease.

This led me to wonder as to the comparative amount of liquid spray that would remain on a watermelon leaf after a similar amount of rain. In a letter to Mr. Page who was working with the growers in the upper territory I asked that he send in two random plants from the fields that had received liquid bordeaux with the power sprayers, which plants had received two good rains following the application of 4-4-50 bordeaux (made from the same brand of dry bordeaux we were using in the dust form). In a letter of August 20th, Dr. Moulton states, "We have completed the determination of copper on the two watermelon plants recently sent us. Although we used the same method as was used previously, we could find no copper in either sample."

It would seem that bordeaux dust need not be applied more often than the liquid form and perhaps fewer applications might suffice.

Attention should here be called to the fact that the bordeaux used for dusting was the dry form, manufactured for liquid spraying and not intended for dusting purposes. A finer product might have given even better results.

Copper dust adheres to the fruit better than does a liquid spray and covers the melons with an even coating at each stroke of the duster. In the work with liquid bordeaux no spreading or adhesive materials were used. These seems little doubt but what future melon spraying will be greatly benefited by the addition of some spreader and sticker to the solution. It also seems well within the realm of reason that a spreader—sticker may sometime be developed that will cause dusting materials to run together and stick to the fruit and foliage after being wet by rains.

Some Interesting Observations

In the Baldwin field containing about two acres of watermelons only 32 rows received dust throughout the season.

There were only two pickings constituting one and one-half car loads made on this field due to early drought and unfavorable market conditions. Eighty per cent of the merchantable melons loaded from this field came from the 32 rows that had been dusted from the beginning to the end of the beetle season, although only about twenty rows had bordeaux dust. Over 90 per cent of the large melons loaded from this field came from these 32 dusted rows. Only partial credit is due to the copper dusts since only 19 of

the 32 had received this material. However, all of the 32 rows had received the most thorough insect fight from the time the cotyledons appeared until the last sign of beetle injury could be noticed. Therefore, it would seem that the plants in these 32 rows had had the greatest possible chance for development with the minimum of loss due to insect injury and possible spread of disease.

One morning while waiting for warmer temperature, in order to make the nicotine dust effective. Mr. Page and I noted some potato plants that were being devoured by Colorado potato beetles. As a matter of curiosity we dusted several rows with 10 per cent strength "Nico Dust" and were most pleasantly surprised to note the rapidity at which the larvae fell to the ground. After counting 23 larvae on one plant we gave it one stroke of the bellows duster and timed the death of the larvae. They immediately became restless, raised their heads upward and were noticed to vomit as noted by Shaffer and fall to the ground. At the end of four minutes the twenty-third larva had fallen to the ground and that evening it was found that none had recovered The morning was cool and cloudy and had the day been warm the killing time might have been reduced. This strength of dust has no effect on the adult potato beetles no matter how much dust is applied to them.

The spotted cucumber beetles were noticed to require nearly twice as much dust and do not succumb so quickly as do the striped beetles. Striped blister beetles are more difficult to kill with 10 per cent Nico Dust than are striped cucumber beetles and one stroke of the duster will rarely kill them as they rapidly walk away from the dust. Several successive strokes of the duster will cause them to die and they apparently require a more saturated condition of the air.

Squash bugs (Anasa tristis) are more difficult to kill with this strength of dust than any of the above mentioned insects. Unless they receive large quantities of the dust they will often recover. The nymphs are more easily killed.

Extension Work in Apple Storage in Massachusetts

By W. R. Cole, *Massachusetts Agricultural College, Amherst, Mass.*

WHILE the horticultural manufactures project of the Massachusetts Agricultural College contemplates food preservation in all products except those of the dairy, the work thus far has been largely with fruit. Vegetable work has received some attention and is being developed as fast as time and staff handicaps will permit.

Extension work has developed most largely in farm storage and farm manufactures. Farm storage applies to both apples

and vegetables, but by far the greater importance lies with apples which are produced in considerable quanities over practically the whole state. Production of winter vegetables in commercial quantities is limited and is confined to small areas close to the large cities. This paper will be confined to a discussion of apple storage.

Apple storage in Massachusetts has up to the present time meant the holding of the crop at points of production, in common or air cooled storages. Considerable quantities have also been packed and stored in commercial storage houses in the cities. Common practice is to pick the apples and place immediately in the storage cellar with no grading or sizing being done until they are packed out for shipment. The greater part of the crop is shipped direct to commission houses or retail handlers. Most growers store in the so-called Boston box, although some use discarded citrus fruit boxes and a few use barrels. The manager of one rather sizable orchard has continuously and successfully practiced the sizing of the crop at time of picking. The fruit is run over a sizer on its way from orchard to storage cellar, and then stored by sizes. This practice enables the grower to immediately locate fruit of a given size for any order received.

Up to the present time the above method of handling has probably been as economical and efficient as conditions have made necessary, since commercial production has been almost entirely of Baldwins. Very many growers in Massachusetts and also the other New England states and New York, are now, or very soon will be, facing the problem of handling large production of other and early ripening varieties. Economical and efficient handling of these crops will make necessary the consideration of artifically cooled storage houses, either individually or collectively owned and located at source of production, or at points of heavy distribution.

Common or air cool storage on the farm as practiced by an increasing number of Massachusetts growers, means the utilization of existing cellars or the construction of cellars purposely built for apple storage.

There are certain principles which are applicable to all individual problems of common storage. First in importance is temperature. The ideal here is 32 to 35 degrees F. This of course cannot be reached in the fall of the year by natural air alone, but a temperature of 38 to 40 degrees may usually be obtained if the storage cellar is properly equipped and handled. An even steady temperature is very desirable. Forty degrees steadily maintained is much better than a 32 degree temperature one day and a 50 degree a week later. Temperature control is dependent upon proper ventilation and adequate air control by means of sufficient and efficient inlet and outlet flues. The best practice is to open all doors, flues etc. during the night and close them during the day.

During the winter 1920-21 the owners of two cellars in different parts of the state were supplied with thermographs which were placed in storage rooms and given careful attention throughout the winter. These two tests give evidence that properly built

and handled storage cellars can be held at an even temperature throughout the season and the department plans an extensive experiment along this line as soon as funds are available. It is not, however, necessary for the grower to use recording apparatus in order to hold his cellar at an even temperature. He does need a reliable thermometer and a willingness to use it.

A certain amount of moisture in the air is necessary for successful holding of apples. In most sections in Massachusetts a dirt floor will provide this degree of humidity. If a cement floor is desired for reasons of ease in handling the fruit and general efficiency the necessary moisture may be obtained by means of running water, or tubs or barrels of water left standing in the cellar. Several of our cellars are so located as to make available the flowage from springs. This not only provides moisture, but is a great help in keeping an even temperature; helping to cool during the earlier season and to warm during the winter cold. Sprinkling of the floors may also be resorted to as a means of providing moisture. In the plan for the temperature control experiment mentioned earlier in this paper, it is intended to include a moisture record. This is to be made by means of sling psychrometer readings taken at regular intervals during the period.

Other general principles are the exclusion of light, proper ventilation and protection from rodents. It is a good practice to build without windows, except where electricity is not available. Ventilation is taken care of by the cooling system. Protection from rodents is provided by covering all openings with three-to-the inch mesh screen wire.

Many growers who already own farms with good cellars which have been abandoned for other uses have by renovation and reconstruction obtained very satisfactory storage sellars. Others have taken old cellar holes and by fixing up and roofing over have provided good storage facilities, and many more might well do so. A large number of such problems have been solved by the extension service through specifications being drawn up for each individual project.

In the case of a grower having a barn cellar that he desires to put into shape for storage use, it is first necessary to thoroughly clean it up. The walls should be pointed up and a concrete footing running down 20 to 24 inches poured in all round at the bottom of the wall. This will usually keep rats from burrowing under the walls to get into the cellar. If the cellar has been used as a manure pit it is best to haul away a considerable quantity of soil from the bottom and replace it with clean sweet earth from the field.

When, as is usually the case, three walls are below ground level no insulation other than the walls and banks will be necessary. In the case of the fourth wall it is usually the practice to provide a packing room on that side. This is separated from the storage proper by a stud and board wall made up of a 2 x 4 studding papered and boarded on both sides. The outlet wall of the packing room is built in the same manner.

The top of the cellar is provided with air insulation between

the floor of the building overhead and a paper and board ceiling. It is good practice to line this ceiling with cellar window wire as a protection against rats.

The cooling system is made up of cold air inlet flues of a total cross-section area equal to one square foot for each 700 cubic feet of space in the cellar. These flues should be not less than 18 x 30 inches in size and should, if possible, be distributed on the three sides of the cellar other than the packing room. They should extend down to within six inches of the floor, be equipped with tightly fitting shutters on their outer end and with efficient slides or dampers just inside the wall line. This combination of shutter and damper gives good protection against the entry of frost.

These inlet flues are complemented by outlet flues leading from the ceiling up into the building overhead. These are best located near the center of the cellar. They are often so placed that they follow the posts along the center driveway of the barn. They are usually of a total cross-section area nearly equal to that of the inlet flues. If carried the full height of the barn and out through the roof the total cross-section area is cut to approximately one-half to two-thirds that of the inlet flues, as increased length of flue will create sufficient suction to make circulation efficient. These outlet flues need not be of the same number as the inlet flues. They are equipped with tightly fitting shutters on their lower end.

The floor is earth in the majority of cases. As before stated this gives, in most locations, sufficient moisture for successful keeping of the fruit. If a cement floor is put in it is nearly always necessary to provide moisture by the introduction of water. This may be piped in from the farm supply and so arranged that trenches running across or around the storage cellars may be filled occasionally as need arises. If may be piped in and a line of pipe run around the ceiling of the storage and from this pipe water sprayed on the walls as need appears and allowed to run down the wall and into trenches at the foot of the wall and thus be carried from the cellar. One very efficient storage house has piped water running from a spring outside into a series of three shallow wells which were built into the storage cellar floor. The water comes from the spring into the first and from that to the other two of these wells and then flows out through a corner of the storage.

The packing room has plenty of windows. If space will permit it is constructed so that the motor truck or wagon can be driven in for ease in loading out fruit. The doors between packing room and storage room are tightly fitted so that it is possible to maintain a comfortable working temperature in the packing room without in any noticeable degree affecting the storage cellar. It is not good practice to locate the packing rooms on the floor above the storage cellar. This makes a heavy load of extra work when packing out the fruit, since all fruit must be brought from the cellar to the packing rooms either by carrying it upstairs or by the installation of some sort of an elevator.

In the case of the old cellar hole being transformed into a storage cellar, much the same procedure is followed as in the above outline for the construction of storage cellars under barns. The ceiling is usually built by running 2 x 6 joints across and paper and boarding them top and bottom. The outlet flues run into the outer air and it is necessary that they be of tight construction and equipped for closing at both ends. Roofs are usually only rafters boarded over and papered or shingled.

New cellars constructed for storage purposes follow the same general principles as outlined for reconstructing old cellars. There is, however, opportunity for greater efficiency in the matter of location. Reconstruction of old cellars must be done on existing locations that are not always absolutely the best. New cellars can be located where the contour of the land and the water conditions of the soil are satisfactory for the best conditions of storage. They are located as near the center of production as is possible, keeping in mind the ease of getting out during the season of shipping the crop. They can always be so placed that three sides are below the ground level. They are planned in size adequate to handle whatever maximum crop is in sight.

The most efficient type of construction is that which has the storage cellar and the packing room on the same level with the building above for storage of empty boxes, barrels, etc., and the orchard and farm machinery. In several problems this upper building was planned with a view to its adaptation and use as a storage should production increase beyond the capacity of the cellar. Growers at present holding winter varieties, but approaching the time of large production of earlier ripening fruits, are building these common storages sufficiently strong in construction and efficient in insulation to permit of installation of refrigerating machinery later.

There are many small and usually unnoticed practices which work for efficiency in handling the crop in the storage.

In a cellar of 10,000 or more bushels capacity a trap door through the floor of the building over head and located at the the end opposite the main door, lightens the burden in putting in the fruit. If the cellar is constructed without a building overhead a door may be placed in the gable of the roof and a trap door in the ceiling. An opening from the upper building direct to the packing room will be found very useful in getting empty boxes when packing out the fruit.

If the cellar has a cement floor a flat truck is an advantage in conveying the fruit to the packing room. With a dirt floor some section of roller conveyors will be found very useful and not expensive.

The dampers and shutters of the cooling system may be so equipped with ropes and pulleys that they may be operated from the packing room.

In the case of new construction it is very often possible to so plan the layout of cellar and packing room that the truck or wagon loaded with fruit may be driven into the cellar and unloaded.

No storage will hold apples in good condition unless it is prop-

erly handled, nor is any storage a bit better than fruit which goes into it. It is of no advantage to try and hold inferior fruit.

Certain well defined practices are established for handling apples in storage.

As before stated the best results are obtained by using boxes as the storage package. The satisfactory temperature may usually be obtained and held by proper attention to the cooling system. Moisture content of the atmosphere may be regulated by control of the water supply. The fruit should be well colored, but not over-ripe; free from blemishes and fungus; carefully picked and handled.

The Massachusetts Fruit Growers Association about a year ago called together the leading apple growers of the state and the Department of Agriculture and College authorities on pomological subjects and brought out a ten year program for fruit growing for Massachusetts.

This ten year program contains the following recommendation with regard to the storage problems of apple production in this state.

1. That every grower whose annual production of winter fruit totals 300 barrels should be equipped for holding his fruit in common storage.

2. That the individual grower with a variety of fruit, fall and winter, and whose aggregate production is 2,000 barrels, should be equipped with a storage plant made up of common and cold rooms or all cold rooms.

3. That groupes of smaller growers whose acreage is so situated as to be reached by not over 5-mile haul to some central point should combine for the purpose of storing their fruits.

4. That need exists for sixteen cold storage plants located in the centers of production for McIntosh and other early winter varieties.

The extension project for 1922 and years following is being and will be built, in so far as it applies to apple storage, around the above recommendations.

Lime Studies With Hydrangeas *

By C. H. CONNORS, *Experiment Station, New Brunswick, N. J.*

HYDRANGEA opuloides, Koch, especially the varieties of the hortensia group, is an important florist's plant, as large numbers are grown for outdoor ornamentation as well as for indoor forcing. The various varieties bear handsome, showy cymes of white, pink (in various shades) or blue flowers.

One difficulty with which commercial florists or distributers have to contend is that certain varieties produce flowers in varying shades of color from pink to blue. It is rather disconcerting

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to business to advertize a variety as bearing attractive pink flowers and then to have it produce a blue-pink or blue flower after it reaches the customer. Florists, therefore, try to grow the different varieties in a way that will cause them to produce flowers of the color described as typical for the variety. Since the cause of the change in color has not been definitely solved, practical florists are continually experimenting with one thing or another in an attempt to control the color.

During the spring of 1921, a nursery and florist establishment which grows thousands of hydrangea plants for distribution and sale, suffered a heavy financial loss because the plants failed to grow properly. A government quarantine of the region in which the greenhouses are located requires the sterilization of all soil in which plants are grown for shipment. Shortly after the soil for repotting the hydrangeas was sterilized with steam the practical florist in charge added considerable amounts of a hydrated lime analyzing about 46 per cent lime and 34 per cent magnesia, with the idea of securing the standard color of flowers upon each variety. Dormant plants were potted in this soil for forcing for the early spring trade. They failed to start well and grew slowly and the leaves became chlorotic. The financial loss was severe and the problem was referred to the New Jersey Experiment Station. It appeared likely that the lime was the cause of the difficulty. Hydrangea plants were therefore furnished by the florist and some lime studies undertaken at New Brunswick in June.

Outline of Experiment

An experiment was planned to test the effect of various amounts and forms of lime upon the vegetative vigor of the plants. The grower supplied the plants, but sent small numbers of many varieties so that the scope of the experiment was limited. Four forms of lime were used :(1) a slaked magnesian lime, analyzing about 47 per cent CaO and 32 per cent MgO, (2) a slaked calcium lime, analyzing about 60 per cent CaO and 2 per cent MgO, (3) a ground magnesian limestone, analyzing about 30 per cent CaO and 20 per cent MgO. (4) a ground calcium limestone, the analysis of which is unknown at the present time, but earlier analyses of the material show a very low percentage of magnesia.

In series I two plants each of two varieties were potted in soil containing 10,000 pounds per acre of slaked magnesian lime and of slaked calcium lime and 4,000 pounds per acre of a slaked magnesian lime and of a slaked calcium lime, with a control of two untreated cultures of each variety. The varieties used are E. G. Hill and Eclaireur.

Series II consisted of two plants of each of two varieties in soil containing 10,000 pounds per acre of ground magnesian limestone and of ground calcium limestone, and 1,000 pounds per acre of slaked magnesian lime and slaked calcium lime, with two untreated cultures of each variety as a control. The varieties used Mme. Auguste Nonin and Souv. de Mme. E. Chautard.

Series III consisted of two plants of one variety to each treatment of 4,000 pounds per acre and 2,000 pounds per acre of slaked

magnesian lime and of slaked calcium lime, and two untreated cultures as a control. Trophee was the variety used.

A sandy loam soil composted with manure was used in this test. This was placed in a box 6 inches deep and firmed, and 10.41 grams per square foot per 1,000 pounds per acre of lime was added and incorporated in the soil as thoroughly as possible. The soil was carefully washed from the roots of the plants (out of 2½ inch pots) and they were potted in 4 inch pots on June 3. They were repotted into 6 inch pots in soils prepared in a similar fashion on August 1. On October 24, final record was made for the season and on October 31 the plants were dried off and put into storage.

Effect of the Lime on the Hydrogen-ion Concentration in the Soil

The initial soil had a pH value of 6.7, about neutral, using the colormetric method as described by Gillespie (1). The addition of such large amounts of slaked lime resulted in only a slight change in the pH value after one month. 10,000 pounds of slaked magnesiam lime per acre gave a pH value of 6.9 while 10,000 pounds of slaked calcium lime gave a pH value of 7.0. The 10.000 pounds per acre of calcium limestone gave a pH of 6.9 as compared with 6.8 for the same quantity of magnesian limestone. Four thousand pounds of slaked lime gave a pH of 6.9 to 7.0 for magnesian and 7.0 to 7.1 for calcium. There appeared to be, therefore, a slight difference in favor of the calcium lime as a corrector of acidity.

The pH values were obtained again after a lapse of one month and just before repotting and practically no change had taken place.

Effect on the Plants

Considerable variation in vigor is found among the various varieties. Trophée and Eclaireur are weaker growing sorts while E. G. Hill, Souv. de Mme. E. Chautard and Mme. Auguste Nonin are vigorous varieties.

At the time of treatment, the plants within the varieties were fairly uniform as to vigor, color of foliage, and root systems.

On October 24, the final records for the season were made upon the plants. The control plants were all vigorous with dark green foliage. The same was true with plants treated with 1,000 pounds of slaked lime of both sorts and 10,000 pounds of ground limestone of both sorts. With the addition of 2,000 pounds of slaked lime, yellowing of the leaves appears, increasing in degree with the amounts applied. With an application of 10,000 pounds of slaked lime, extreme yellowing took place, the plants of the variety Eclaireur, which is a very weak growing sort, so treated were much dwarfed and nearly dead, the foliage having the appearance of typical iron chlorosis.

Very slight differences were noted in the action of the calcium lime as compared with the magnesian lime except in the 4,000 pounds and 10,000 pounds of slaked lime applications. In

these cases the plants treated with magnesian lime were poorer than those treated with calcium lime.

CONCLUSIONS

In this preliminary work, the one apparent effect of the lime as used, was to check the growth of the plants in the case of some applications. The small applications of slaked lime, or heavy applications of ground limestone, were apparently not injurious to the plants. When heavier applications were made of slaked limes, decided effect was seen upon the growth of the plants in the form of partial or almost complete chlorosis. The heavier applications of slaked magnesian lime appeared to be more injurious than the pure calcium lime. The conclusion to be drawn from this experiment is that it is safer to use upon hydrangeas lime free from, or low in, magnesia, and that the amount used should be no more than just enough to bring the soil to a neutral, or very slightly alkaline state. Upon a neutral soil the limit of safety appeared to be 1,000 pounds of slaked lime per acre, but ground limestone was used with safety at the rate of 10,000 pounds per acre.

SUMMARY

Hydrangeas are an important greenhouse crop, but the susceptibility of most varieties to a not definitely known physical or chemical condition of the soil, resulting in the changes in color of the flowers, requires the utilization of special methods of culture.

Some practical growers believe the presence of iron in the soil to be the contributing factor, and that large amounts of lime would prevent the action of the iron upon the color.

Plants were grown in a neutral sandy loam soil to which was added 1,000, 2,000, 4,000 and 10,000 pounds per acre of slaked calcium and magnesian lime and 10,000 pounds per acre of ground calcium and ground magnesian limestone. The excessive amounts of lime did not materially increase the hydrogen-ion concentration in the soil.

The control plants and those growing in the limestone treatments and the 1000 pounds per acre of slaked lime treatments, maintained a vigorous growth. The application of these amounts upon the neutral soil used appeared to be safe. Those growing in soils treated with 2,000 pounds, 4,000 pounds and 10,000 pounds per acre of the slaked limes, became chlorotic, varying directly with the amounts added. The highest application practically prevented growth, due principally to iron chlorosis. Magnesia seemed to have a slightly toxic effect in the highest amount.

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Effect of an Early Application of Nitrogen on Peach Trees Deficient in Vigor*

By M. A. Blake, *University of New Jersey, New Brunswick, N. J.*

DURING the spring of 1907 the horticultural department of the New Jersey State Experiment Station established an experimental peach orchard of 675 trees at Vineland, as another unit of the general plan to stimulate the peach industry of the state.

The orchard was located upon a sandy loam soil typical of the section. It had been neglected for a number of years and had not, therefore, been tilled or fertilized for some time.

The orchard planted in 1907 was set to the variety Elberta with other varieties set every sixth row in either direction. This separated the Elbertas into blocks 5 trees square making a total of 25 trees. These blocks of 25 Elbertas then received a series of fertilizer treatments one of which was a comparison of the effect of different amounts of nitrogen. One series of plots received at the beginning a mixture of 150 pounds high grade sulfate of potash, 100 pounds ground bone and 200 pounds of acid phosphate per acre. After the trees came into bearing all the phosphoric acid was furnished in 400 pounds of acid phosphate per acre.

Young peaches may start and grow fairly well upon the sandy soils of southern New Jersey if they receive thorough tillage. This was the case with the trees in the first orchard at Vineland even where the soil had been neglected and practically no nitrogen was applied except the very small quantity in the ground bone, for the first few seasons.

After the trees began to bear, however, those in plots receiving no nitrogen gradually became more yellowish green in color and made less and less twig growth until by 1914 they looked yellow and sickly even under thorough clean tillage and the fruit was also under size. It was also observed that as the trees lost vigor each year many of the smaller roots died. In other words, a loss in vigor of the roots was correlated with a loss in vigor of the tops of the trees. The trees were set 15 feet apart each way to test the effect of close planting and this fact no doubt helped to accentuate the effect of the lack of nitrogen. The trees were kept pruned back and within bounds, however. In other words, they were kept in high class commercial condition except for the fact that the blocks of trees mentioned in this paper received practically no nitrogen. It was not infrequently recommended some few years ago that peaches receive a fertilizer containing largely potash and phosphoric acid and little or not any nitrogen. It has since been shown in Deleware, West Virginia, New Jersey and elsewhere, that nitrogen is an important plant food element in the culture of peaches. The general fertilizer results secured in the Vineland experiments do not concern the feature of this paper and will, therefore, be omitted.

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*Paper No. 64, of the Journal Series, New Jersey Agricultural Experiment Stations, Department of Horticulture.

Five of the plots had reached such a point of decreased vigor by 1915 that it appeared to be of more value from an investigational standpoint to study the stimulating effect of an application of nitrogen to such trees rather than to continue the starvation process and allow the trees to gradually die from lack of nitrogen.

Plan of the Experiment

Since the blocks were 5 trees square it was possible to broadcast nitrate of soda across one half of each block and leave the other half untreated and have 10 nitrated trees, 10 check trees and 5 which would receive about one-half the regular amount of nitrogen.

This plan was carried out and nitrate of soda at the rate of 200 pounds per acre was applied to the west half of each of the 5 plots treated in very early spring just as growth began.

Effect of the Nitrogen upon the Set of Fruit

Since the trees had made but very little growth during 1914 the set of flower buds and the resulting bloom upon all trees upon the plots was comparitively light in the spring of 1915.

The effect of the early application of available nitrogen became quickly apparent.

The blooms upon the check trees failed to make as high a percentage of set as upon the nitrated trees and the drop in June was heavier and continued to some degree into late summer.

Practically every fruit appeared to set and grow upon the nitrated trees and there was no late dropping of large fruits in July.

These results with peaches are comparable to those secured by Lewis with apples in Oregon. It is of interest to note further that these results with both peaches and apples were secured at about the same period although the results with peaches were not published in the form of a paper at the time.

Other experiments in New Jersey have shown that the reserve of starch stored in the roots and branches of the trees during the late summer and fall is practically exhausted by the time the young fruits are about one-half to three- quarters of an inch in length and that this is correlated with the period of the so-called "June drop".

It is not surprising, therefore, that trees markedly deficient in vigor are able to retain a larger percentage of their set of fruit if supplied with quickly available nitrogen as soon as growth starts in early spring.

Effect upon the Final Crop in 1915

The nitrated trees in the Vineland experiments became dark green in color as they came into full leaf in comparison to the lighter and more yellowish green of the check trees, and this difference grew more pronounced as the season advanced.

The first picking of fruit was made on these plots on August 16. At that time the fruit upon the check trees was beginning

to ripen and the bulk of it was ready for harvesting for shipment between August 20 and 23rd. Practically all of the fruits were small and they packed 12-12-12 in Georgia carriers. In other words, the circumference of the fruits upon the check trees averaged about 6½ to 6¾ inches which is decidely small for Elberta. The fruits were highly colored and firm fleshed as would be expected, but were below good commercial size.

The fruit upon the nitrated trees ripened more slowly and most of the crop was harvested from August 23 to August 27 with a final picking on Plot 4 on September 3rd.

The rate of ripening was in proportion to the amount and rate of growth of the indiyidual trees.

The size of the fruits upon the nitrated trees was in marked contrast to those upon the checks. As stated at the beginning, the set of fruit was not heavy because of the limited amount of wood growth and the specimens were, therefore, quite uniform as to size. The majority packed 8-7-8 in Georgia carriers and a considerable proportion 6-6-6. The peaches from the nitrated trees, therefore, ranged in size from about 8 to 8¼ inches in circumference in comparison to less than 7 inches in circumference for those from the check trees.

Effect Upon the Dividing Rows

As noted in the beginning the center or dividing rows only received an application of nitrate from one side and that side showed the effect much more quickly than the other. In fact, the check or no nitrogen side of some of the trees of the dividing rows remained much like the check trees in appearance for some time. The crop upon such trees ripened over a longer period and there was a greater variation in the size of the fruits than upon the trees receiving their full share of nitrate from all sides.

Comparison of Yields

Yields may be compared in several ways including, (1) individual trees, (2) lots of 100 trees, or (3) per acre.

Since the trees in this experiment were set 15 x 15 feet apart and were kept cut back the average yields and the differences per tree are smaller than under greater planting distances and it appears more nearly correct and fair to report the yield on the acre basis rather than per individual tree.

The actual area of the orchard was 3.75 acres with a 15 foot wide strip around the entire orchard as a "headland," and the total number of trees planted was 675, making an average of 180 trees per acre. The yields are, therefore, reported in terms of 16 quart baskets per acre of 180 trees. The standard bushel for peaches in New Jersey is 48 pounds and this is the standard recognized in most states.

Yields of Peaches in 16 Quart Baskets Per Acre.

Plot	Check Trees Baskets	Line Trees Baskets	Nitrated Trees Baskets	Excess over Check Baskets
4	574.7	628.	1195.3	620.6
8	559.1	954.3	1312.5	753.4
12	695.5	991.1	1254.5	559.0
15	765.6	760.3	1233.4	467.8
16	618.4	758.8	1067.5	449.0
Average	642.6	818.5	1212.6	570

The crop upon the trees receiving the early application of nitrogen was also worth considerably more per basket than the fruit upon the check trees because the latter fruits were small in size. All of this fruit was shipped and sold through large commission dealers and the selling price of small Elbertas of a 12-12-12 pack was actually about $1.25 to $1.50 per crate while for sizes as large as an 8-7-8 or a 6-6-6 pack it was about $2.00 per crate.

The effect of the early application of nitrogen to the weakened trees in the Vineland experiments was very striking and definitely showed that quickly available nitrogen applied just as growth starts may hold a set of fruit upon trees so deficient in vigor that they otherwise would be unable to support a crop.

Effect of an Early Application of Nitrogen to Trees in Full Vigor.

The report of these results would not be complete, however, without a statement as to the effect of nitrogen upon peach trees that are already growing rapidly, since the effect is quite different from that upon trees growing very slowly. It is quite generally understood that young trees can be made to grow so rapidly that fruit production is delayed for a time. This is not true to the same degree with peaches as with apples, but it sometimes occurs.

Peach trees in eastern districts at least will not infrequently drop most of their crop of fruit during their third and fourth seasons of growth if over stimulated with nitrogen. Excessive wood growth also delays the time of ripening of peaches and this is usually objectionable with early ripening sorts such as Carman. No one wants to buy early semi-clingstone peaches after the better freestone varieties ripen and the price drops accordingly.

Size of Fruits Largely Determined by the Number on the Tree

One should not expect an early application of nitrogen to bearing trees in good vigor to produce the same marked results in increasing the size of the fruit as occurred at Vineland upon trees deficient in vigor for several reasons. First, the fruit upon the check trees at Vineland was smaller than that produced by normally vigorous trees while the fruit from the trees receiving nitrogen averaged larger, thus the gain or difference in size was exceptional.

Bearing peach trees in full vigor set a heavy crop of fruit under favorable conditions and the only way that the individual specimens can be developed to an exceptional size is to reduce the number of specimens. An application of readily available nitrogen may be good orchard practise and help a heavily loaded tree to mature its crop and make a satisfactory growth, but it will not greatly increase the size of the fruits on the tree if they are at all numerous.

There were plots in the Vineland orchards which received liberal amounts of nitrogen annually early in the season and they adjoined the plots receiving the special nitrate treatments so a most favorable chance for a comparison was provided.

The question may then be raised as to why the nitrogen so markedly increased the size of the fruits upon the weakened trees. When bearing trees slow down in growth and the bark becomes hardened the translocation of elaborated plant food is inhibited to some degree. If growth is then stimulated the effect is somewhat similar to partial girdling or ringing. A large proportion of the elaborated food manufactured as a result of the increase in foliage is used for the development of the fruit and is commonly of large size. By the second year the effect is not likely to be so pronounced if the trees have largely overcome the former checked condition.

The set of fruit upon the nitrated trees at Vineland was only medium because of the limited twig growth the previous year and the checked condition of the trees followed by the stimulus to growth was exactly the right combination of conditions to produce extra large fruit of fine color and quality in 1914.

To summarize, when trees are deficient in vigor they should receive an application of quickly available nitrogen as soon as growth starts in early spring. It will assist them to set and hold a crop of fruit and make wood growth early in the season when it should be made. Trees which are already making an exceptionally free vegetative growth, however, will often produce fruit of better color, more firm flesh and better quality, if they do not receive any additional nitrogen for a time.

The relative vigor of the tree will therefore determine the nature of the results which may be secured by an early application of quickly available nitrogen to peaches.

Nitrogen Reserve in Apple Trees

By R. H. Roberts, *University of Wisconsin, Madison, Wis.*

When discussing the project of conducting nutritional experiments with potted trees in the greenhouse, at the Chicago meeting, the following statement was made: "It is planned that manipulation and study of these trees will give evidence of the accumulation, nature, distribution and utilization of the reserve materials in the wood. At present it may be stated that under conditions of low nitrogen nutrition, the type and appearance of

foliage and growth are more influenced by the composition of the wood, as a result of previous treatment, than it is by the current seasonal conditions.'' That is, it had been observed that trees which were previously poorly vegetative, made little growth when maintained in a low nitrogen nutrient, as would be expected; on the other hand, trees which were previously very vegetative made an excellent growth after being transferred to a low nitrogen nutrient. The amount of growth made was somewhat unexpected. Similar hold-over effects from the use of nitrate of soda have been frequently noted in connection with orchard fertilizer work. For example, Lewis and Allen* state that ''its effect will extend over into a second season and perhaps longer.'' It appears that the idea has usually been that a change in soil composition gave the continued effect from single season's applications of nitrogen in the orchard.

With regard to the potted trees, it was presumed that the factor which caused the difference in growth of these trees was the diffenence in reserve nitrogen contained in the tree as a result of previous treatments A definite statement of this opinion was withheld in 1920 pending further verification. It is believed that sufficient evidence is now available to warrant the statement that apple trees can develop and utilize a nitrogen reserve as well as create and respire a carbo-hydrate reserve. The accumulation of a nitrogen reserve in trees depends, of course, upon nitrogen being supplied in the nutrient, as contrasted with the accumulation of a carbo-hydrate reserve by means of the photosynthetic mechanism of the plant.

A summary of some results secured in 1921 are presented in the following table:

TABLE I

Relation of Nitrogen Content and Growth of Dwarf Wealthy Apple Trees; Analysis of Branches.

Nitrogen content of 1920 nutrient	1921 Nutrient	Average growth of trees 1921, centimeters	Percentage of nitrogen in branches		
			Beginning of growth	After harvest	Percentage change in nitrogen
High nitrogen	High nitrogen	137.4	.99	.90	— 9.09
	No nitrogen*	126.6	.99	.32	—67.6
Low nitrogen	High nitrogen	92.3	.66	.94	+42.4
	No nitrogen*	52.2	.66	.29	—56.1

*Traces in tap water.

The analyses of trunks, roots and new growth are not yet completed, but those of the branches (two years' growths between

*Lewis, C. I. and Allen, R. W. The influence of nitrogen upon the vigor and production of devitalized apple trees. Report of the Hood River Oregon Branch Experiment Station for 1914-1915.

the trunk and new growth of four year old trees) should be representative of the trees. It will be noted that the high nitrogen trees of 1920 which received nitrogen again in 1921 made a strong growth and maintained a consistently high nitrogen content; those from which nitrogen was withheld made nearly as much growth as those receiving nitrogen, but in doing this *their nitrogen content was reduced by two-thirds.* The low nitrogen trees of 1920 which received no nitrogen in the nutrient in 1921 had their nitrogen content reduced over one-half in making very little growth; when supplied with nitrogen, this latter type of tree made a good growth and *gained forty per cent in nitrogen content.* These facts are considered as indicating that nitrogen compounds may be present in significant amounts as a reserve material in apple trees under conditions of high nitrogen in the nutrient.

No attempt is made in this note to discuss the details of the experiment. These will be presented later in a report in cooperation with the Department of Agricultural Chemistry which is making the chemical analyses. It should be added, however, that the carbohydrate compounds which have been determined to date decrease with an increase in nitrogen content, and increase with a decrease of nitrogen. Also, abundant blossom bud formation occurred only on the trees which had an intermediate percentage of nitrogen and the reciprocal condition of an intermediate percentage of carbohydrate reserves. The nitrogen starch and sugar composition of the branches at about the time of bud formation is given in the following table.

TABLE II.

Percentages of Starch, Total Sugar and Total Nitrogen in Branches at Cessation of Terminal Growth, 1921.

Vegetative condition of trees 1920	1921	Blossom bud formation 1921	Total nitrogen	Total sugar	Starch
High	High	Slight*	98	1.85	3.85
High	Medium	Abundant	.50	2.20	4.76
Low	Medium	Abundant	.87	2.31	5.22
Low	Low	None	.20	2.88	6.10

*The most vegetative trees formed no blossom buds.

Transpiration Rate of Deciduous Fruit Trees As Influenced by Irrigation and Other Factors

By A. H. HENDRICKSON, *University of California, Berkeley, Calif.*

THE need of water for irrigation of deciduous orchards in many sections of California is paramount. The growth and vigor of the trees and the size and amount of fruit are closely linked up with the use of water at the proper time. In spite of the importance of this factor, irrigation practice with deciduous orchards is derived practically altogether from empirical data.

There is a lack of uniformity of opinion as regards the best methods of irrigating prunes, peaches, pears, apricots and other fruits in different districts, or even within a given district.

The following paper is a preliminary report on a project on irrigation of deciduous fruits being carried on by the divisions of Irrigation Investigations and of Pomology of the College of Agriculture of the University of California. In the course of the experiments with mature deciduous fruit trees, it was found that there was a very great loss of moisture from the soil within 48 hours after application. This loss was not due to evaporation directly from the surface of the soil nor to loss of moisture by percolation below the root zone as was ascertained by sampling the soil to a depth of twelve feet. In other words, when the soil was wetted to its full field capacity to a depth of six feet, frequent samplings showed that the downward movement of moisture below the sixth foot was so slight it was negligible. The extremely rapid depletion of soil moisture could only be accounted for through transpiration.

A series of transpiration tests were made of trees of different species and ages, before and after irrigation. A part of the work was done on large trees using the cobalt paper method and the results checked against small trees grown in potometers. The potometers used were metal tanks containing approximately 1000 pounds of soil which were weighed frequently. All precautions were observed to prevent loss of any moisture except through the leaves. The readings obtained by the cobalt paper method, while only approximations, were so consistent that it is believed they form a basis for comparison at least. The cobalt paper method of obtaining transpiration readings, while not satisfactory, was the only one that could be used with mature, bearing trees.

The data obtained are in the nature of a measure of the availability of the water in the soil, rather than a measure of the actual amount used or the need of a given tree for water. The readings gave only a comparative idea about the amount of water being used by the trees under different treatments and verified the results obtained by soil sampling at stated intervals.

Weather Conditions

The experiments were conducted at Davis under conditions fairly typical of the great interior valleys of California. The days were warm and clear and the nights fairly cool. Dry north winds prevailed at different times for intervals of two or three days. At other times, due to local topography, there was usually a cool breeze from the southwest which began about 4 o'clock in the afternoon. Maximum temperatures of 100° F. were not unusual and in one case a temperature in excess of 110° F. was reached on two successive days. The maximum temperature was reached about 2 o'clock in the afternoon.

Experimental Results

It was found that there was a marked variation in the rate of transpiration due to the position of different leaves on the branch. Under equal conditions of sunlight the young leaves to-

ward the growing end of the branch transpired more slowly than the older leaves situated near the base of the branch. This fact held true for prunes, peaches, pears and apricots. Branches actively elongating, and those with terminal buds formed, both gave the same results. The readings were made from June to September. In 1921 a few readings taken early in April before the branches had made any considerable length growth did not show the differences mentioned above obtained on the slightly older and longer growth in mid-summer. Apparently the young leaves at the apex of the branch were unable to obtain sufficient water to enable them to transpire as rapidly as those situated near the base of the branch. In still another series of readings it was found that spur leaves on two year wood on prunes and pears transpired faster than leaves on shoots of the current season.

The rate of transpiration increased after eight A. M. until from 11 A. M. to 1 P. M. Thereafter the rate fell off until between 5 and 6 P. M. when the last readings were usually taken. The leaves were apparently unable to secure sufficient moisture to enable them to continue to transpire at the highest rate. Evidently a deficit of water occured in the conducting tissue. This deficit under interior valley conditions occured daily regardless of the amount of water in the soil. With an abundance of water in the soil the falling off in the rate of transpiration usually occurred somewhat later in the day than in the case where the soil was drier.

In one experiment with mature prune trees bearing a fair crop, water was applied on July 27 in one plot to wet the soil to a depth of six feet. Cobalt paper readings were taken from comparable leaves on the irrigated trees and also in similar trees not irrigated. Readings were taken from the third and fourth leaves from the end of the branches having terminal bud formed. The data secured showed that on July 28 transpiration was greater throughout the day on the irrigated tree than on the unirrigated tree. On July 29 the rate for the irrigated tree was faster than the unirrigated until 2 P. M. On July 30, the third day after irrigation, no difference in rate of transpiration could be detected after 9 A. M. The soil around the irrigated trees at that time was still too wet to be cultivated. In other words the effect of an irrigation of approximately ten acre inches was lost forty-eight hours after the application as far as the rate of transpiration was concerned. It is interesting to note also that the irrigated tree when transpiring at a rapid rate twenty-four hours after water was applied, still showed a decrease in rate of loss in the afternoon. This decrease was somewhat less marked than in the case of the unirrigated tree. Essentially the same results were obtained with mature Muir peach trees, mature Royal apricot trees and young Bartlett pear trees.

With the foregoing prune trees the average moisture content of the top six feet of soil in the unirrigated plot was practically down to the hygroscopic point. The moisture content of the soil in the irrigated plot was approximately 21 per cent immediately after the water was applied, and on July 30 or three days after irrigation the amount of water in the top six feet of soil was 15.6 per cent.

A Preliminary Experiment on Half Tree Fertilization

By H. E. KNOWLTON, *West Virginia University, Morgantown, W. Va.*

IN any investigation with fruits trees, the individuality of the trees is always an unknown factor. Differences in soil, stock and often in scion, affect the response of each tree in the orchard to any particular treatment.

In planning some nutrition experiments on apple sterility, the author decided to gather some evidence on the question of fertilizing portions of trees and leaving the remaining parts as checks. If this could be done it would obviate the factor of tree individuality. Heinicke (1919) noted that when nitrate of soda was spread under portions of apple trees, the limbs immediately above the area where the fertilizer was applied, retained their leaves later in the fall. This would suggest that particular roots of a tree supplied the limbs above with nutrients.

In the spring of 1921, three twenty-five year old Rome Beauty apple trees were selected which were on a hillside each with one fork pointing up and the others down the slope. Several weeks prior to blooming time, nitrate of soda was applied to the lower sides of the trees. At intervals after the application samples of buds and leaves were taken from both sides of the tree fertilized with 5 pounds of nitrate of soda. Total nitrogen analyses were made from each of these samples. Results of these analyses were briefly as follows. On the fifth and eighth days no noticeable differences were evident between the nitrogen content of the opening fruit buds on the two sides of the tree. On the twelfth day the buds on the fertilized side showed 43.5 milligrams of nitrogen and on the unfertilized side 30.9 milligrams of nitrogen per gram of dry weight. On the twenty-first day, analyses of the leaves on the fertilized side showed a nitrogen content of 17.4 milligrams, and on the unfertilized side a nitrogen content of 12.9 milligrams per gram of dry weight. No further analyses were made until fall when current growth samples were taken from the two sides. No significant differences could be found in the nitrogen content of these samples. Analyses of other portions of the two sides of the tree might have shown a difference. It is significant, however, that no hold-over effect is evident in the current season's growth. Growth measurements next year should prove interesting.

In order to get a further measure of the differences between the two sides of the trees, terminal growth measurements were taken after elongation had ceased. From one hundred to two hundred terminals were measured on each side. The following table shows the results.

Tree	Nitrate of soda added (pounds)	Average of terminal growth (inches) fertilized side	unfertilized side
Rome Beauty	9	8.6	6.9
Rome Beauty	5	7.5	5.8
Rome Beauty	3	9.7	8.8

A study of the above data shows that the limbs on the fertilized side received more of the nitrogen than did the other unfertilized side. There is no indication as to the amount that passed to the unfertilized side if any. More extensive tests must be made to ascertain this. Undoubtedly the amount of crossing over will be influenced by the arrangement of the roots. Often roots are found on one side of a tree that join the trunk on the opposite side. The length of trunk is also important—the longer it is the more opportunity for tranverse diffusion through medullary ray cells.

Increased amounts of nitrogen were evident in the opening buds after twelve days. Weather and soil conditions undoubtedly are important in affecting the rate of intake by the roots and the subsequent passage upward of the nutrient. When nitrate was applied the soil was unfrozen. Late in day rain fell. From the third to the eighth day following the application the temperature ranged around 80° F. during the day and around 55° F. during the night.

About ten days after nitrogen was applied, the opening blossoms on two of the trees were emasculated and bagged. Several days later the temperature went down to 24° F., killing 80 to 90 per cent of the opened flowers in the orchard. Counts were made of the percentage of live bagged pistils on the treated and untreated sides of the trees. The following results were gotten. On the tree fertilized with 3 pounds of nitrate of soda, 21.1 per cent of the pistils were alive on the fertilized side and 11.2 per cent on the unfertilized side. On the tree fertilized with 5 pounds of nitrate of soda, 15.5 per cent of the pistils were alive on the fertilized side and 10.7 per cent on the unfertilized side. Two thousand pistils were included in this count, five hundred from each side of the two trees.

Since so few pistils were alive only a limited number of pollinations could be made. Pistils were pollinated using pollen from the same sides of the trees. Pollen was applied on the pistils of the two sides of each tree at the same time, in order that germination and tube growth might occur under the same conditions. Samples of pistils were taken at definite intervals after pollination, killed and preserved for microscopic study. At the present time only a small number of pistils have been dissected. Indications are, however, that pollen tube growth is more rapid in pistils from the fertilized sides of the trees. More material will need to be studied to fully establish this point.

The author wishes to emphasize the preliminary nature of this experiment. Because of its limited nature no explantions or reasons will be advanced for the results gotten until more data have been collected.

The Season of Application of Nitrogenous Fertilizer as Affecting the Chemical Composition of Spurs and Bark

By H. D. Hooker, Jr., *University of Missouri, Columbia, Mo.*

APPLICATIONS of nitrogenousfertilizers to apple trees may conceivably affect yields through influencing the size of the trees, the setting of fruit or the differentiation of fruit buds. Each of these processes is associated with definite conditions of chemical composition at critical seasons. Data presented here show certain effects of fertilization with nitrogen in a readily available form on the percentage content of starch and total nitrogen in spurs at times which are known to be decisive for specific physiological processes. The analyses reported for Jonathan and Ben Davis were made on seven year old trees which blossomed for the first time the year after the samples were collected. The York Imperial trees referred to were pronounced biennial bearers; those sampled in the bearing year were 20 years old, those sampled in the off year were 16 years old. All the trees were in good condition.

Fruit bud differentiation in apples is generally associated with starch accumulation in the spurs late in June. Consequently the effect of spring applications of quickly available nitrogenous fertilizers on the starch content at this time should give an indication of their tendency to increase or decrease fruit bud differentiation. The data in Table 1 show that in the latter part of June the percentage starch content of non-bearing spurs on spring fertilized trees is in all cases less than that of the spurs on the check trees. Furthermore there is no tendency toward accumulation of starch in bearing spurs on spring fertilized trees, the figure for the ammonium sulphate spurs being too small to be significant under the conditions of analysis. Spring fertilization with nitrogenous fertilizers cannot, therefore, be expected to increase directly the percentage of fruit bud differentiation. As the analyses reported were made on a large number of spurs and present averages only, it is probable that some of the spurs on nitrated trees contained very little if any starch.

TABLE I

Starch Content of Spurs at the End of June as Affected by Nitrogen Applications the Previous March

(In percentages of dry weight)

	Non bearing spurs	Bearing spurs
Jonathan		
Nitrate of soda	1.60	—
Check	2.16	—
Ben Davis		
Nitrate of soda	1.10	—
Check	1.42	—
York		
Nitrate of soda	—	0.00
Ammonium sulphate	—	0.36
Blood	1.87	0.00
Check	2.88	0.00

Fruit setting, according to Harvey and Murneek's recent work, is associated with a high nitrogen content in May. The data in Table 2 show that spring applications of nitrogenous fertilizers increase the percentage nitrogen content of spurs in May in non-bearing as well as in blossoming spurs. This tendency is in accord with the well recognized influence of spring nitrogen applications in favoring the set of fruit.

TABLE II

Nitrogen Content of Spurs in May as Affected by Nitrogen Applications the Previous March

(In percentages of dry weight)

	Non-bearing spurs	Bearing spurs
Jonathan		
Nitrate of soda	.927	——
Check	.857	——
Ben Davis		
Nitrate of soda	.822	——
Check	.699	——
York Imperial		
Nitrate of soda	——	1.047
Ammonium sulphate	——	1.164
Blood	.800	1.221
Check	.773	1.020

It is interesting to observe the residual influence of spring applications of nitrogen as revealed in the percentage nitrogen content of the spurs a year later. Table 3 shows that there is no consistent tendency for the spurs on spring fertilized trees to have more or less nitrogen than spurs on check trees. Table 4 shows that exactly the same statement holds for the bark from the scaffold limbs of both bearing and non-bearing York Imperial trees. Although the percentage nitrogen content of the bark and spurs is not materially altered one way or the other, it is evident that the absolute nitrogen content of the tree would be greater if the bulk of the tree had been increased and the percentage nitrogen content of its parts were not affected.

TABLE III

Nitrogen Content of Spurs in March as Affected by Nitrogen Applications in March of the Previous Year.

(In percentages of dry weight)

	Non-bearing trees	Bearing trees
Jonathan		
Nitrated	1.23	——
Check	1.35	——
Ben Davis		
Nitrated	1.245	——
Check	1.30	——
York Imperial		
Nitrate	——	0.92
Ammonium sulphate	——	0.89
Blood	0.92	0.88
Check	0.85	0.86

TABLE IV.

Nitrogen Content of Bark in March as Affected by Nitrogen Applications In March of the Previous Year

(In percentages of dry weight)

	Non-bearing trees	Bearing trees
York Imperial		
Nitrate	——	0.62
Ammonium sulphate	——	0.52
Blood	0.68	0.56
Check	0.65	0.58

The data in Table 5 show that it is possible to increase the percentage nitrogen content of spurs in the spring. The later the nitrogenous fertilizer was applied the previous season, the greater was the nitrogen content of the spurs the following March. Moreover the differences recorded are appreciable. No significant differences were produced in the nitrogen content of the bark on the scaffold limbs, however. Severe spring frosts made is impossible to continue the study of these trees and to measure the effects of these different treatments in terms other than those of chemical composition.

TABLE V

Effect of Season on Nitrogen Application on Nitrogen Content of York Imperial Trees the Following March

(In percentages of dry weight)

	Spurs	Bark
Check	0.85	0.65
Spring application of blood (March 20)	0.92	0.68
Summer application of blood (June 24)	1.01	0.65
Fall application of nitrate (September 20)	1.17	0.70

The facts presented demonstrate the importance of studying the effects of fertilizer treatments in terms of individual physiological processes, such as fruit setting and fruit bud differentiation, rather than in terms of ultimate yield. They indicate that a treatment which favors fruit setting probably does not favor fruit bud differentiation. Evidently the fertilizer problem is not a single question of determining a requirement of nitrogen and supplying it at some one standard time. It involves as many separate problems as there are individual processes to be affected.

The Effect of Certain Potassium and Nitrogen Fertilizers on the Shoot Growth and Flower Formation of the Peach

By W. A. RUTH, *University of Illinois, Champaign, Ill.*

THE experimental orchard in which the following measurements were made is located at Olney, Illinois. The orchard was started from June buds planted in the spring of 1917. In 1920 the orchard bore its first crop. The results strikingly favored the

plats to which either nitrogen or potassium fertilizers, or both, had been applied. A general description of the orchard and some of the results were presented before this society in 1920 by Prof. B. S. Pickett.

Professor Pickett's paper dealt with the detrimental effect of cow peas and rye upon the yield, and the fact that the effect of cowpeas was partially or fully overcome by the use of certain fertilizers. The effect of cowpeas was partially corrected by the use of sodium nitrate alone, completely corrected by the use of potassium sulphate alone, and the use of both potassium sulphate and sodium nitrate resulted in a yield somewhat in excess of that on the corresponding clean cultivated plats. That potassium sulphate was modifying the development of the trees growing in cowpeas was thereby clearly shown. An additional and important fact not dealt with in the above paper was the beneficial effect of potassium sulphate upon the yield of trees grown under clean cultivation. No matter what other fertilizers were applied to the clean cultivated plats potassium sulphate invariably increased the yield. These general conclusions, drawn from the yields of 1920, are confirmed by Professor Pickett's estimates of the comparative bloom of 1921. Potassium sulphate and sodium nitrate had the same general effect upon the bloom of 1921 that they had upon the yield of 1920. The effect of potassium sulphate alone is again brought out. The estimates of bloom are included in Proffessor Pickett's paper presented before this meeting. Plain differences were also observable in the summer of 1921 between the size of the trees growing in cow peas without fertilizer and the size of those growing in cow peas with sodium nitrate or potassium sulphate.

In an effort to determine peculiarities of development which could be associated with the increased yield following the application of potassium and nitrogen fertilizers and to determine the effect of potassium sulphate itself, a number of measurements were made. Measuring was confined to trees on the cultivated plats. When the trees were in bloom in 1921, shoot growth made in 1920 was measured and flowers formed in that year were counted and their location was determined. A series of severe frosts following the early blossoming of 1921 entirely destroyed the crop. A second set of measurements was made in September to determine the growth made in 1921.

It was though that differences between the plats could be determined more accurately by measuring a few trees than by making an equal number of like measurments on a larger number of trees. Although the trees in each plat were fairly uniform in general appearance, the trees which seemed to be most representative of the average were chosen. These included one tree receiving a light application of sodium nitrate (¾ pound); one receiving a light application of both sodium nitrate (¾ pound) and potassium sulphate (½ pound) one receiving a heavy application of sodium nitrate (6 pounds) one receiving a heavy application of both sodium nitrate (6 pounds) and potassium sulphate (4 pounds); and one tree receiving no fertilizer. Fertilizers had been applied at or before the blooming period every spring.

The measurements made during the blossoming period of 1921 included the total length and diameters of a part of the shoots developed on each tree during the previous season. No selection of shoots was made; all the new growth on the southwest part of each tree was measured. Shoots were calipered near the proximate end and at each bud. Flowers were located according to the quarters (in length) of the shoots on which they were borne.

After the records were made the shoot measurements from each tree were separated into groups according to length. Shoots one centimeter and less in length constitute one group; the next group contained those from 1 cm. to 5 cm; above this length groups were made at 5 cm. intervals up to 40 cm. Those 40 cm. long and longer together constitute a final group. Secondary shoots and shoots bearing secondaries have been kept separate; such shoots bore few flowers and were not a factor in production. They are not considered in this paper. Diameters of shoots of a length of 5 cm. or less are not included in the data regarding diameter because of the inaccuracies involved in calipering such short shoots. Shoots one centimeter or less in length, moreover, bore almost no flowers (none at all on the unfertilized trees), but shoots between one and five centimeters bore flowers freely. The shortest shoots, are, therefore, included in considering the relation of length and flowering. Satisfactory numbers of measurements of shoots in the groups above 25 centimeters were not always obtained.

Table I presents the data upon which the statements immediately following are based.

TABLE I

Diameter of Shoots of Different Lengths at Flower and Leaf Buds and at Base

Treatment	5-10 cm.			10-15 cm.			15-20 cm.			Average		
	Base	Flower	Leaf	Base	Flower	Leaf	Base	Flower	Leaf	Base	Flower	Leaf
Check	.24	.20	.21	.26	.18	.21	.29	.18	.23	.26	.19	.22
$NaNo_3$ light	.28	.23	.23	.32	.26	.28	.34	.25	28	.31	.25	.26
$NaNo_3$ K_2 SO_4	.20	.16	.20	.23	.18	.21	.28	.19	.21	.24	.18	.21
$NaNo_3$ Heavy	.28	.22	.26	.29	.23	.26	.35	.27	.26	.31	.24	.26
$NaNo_3$ K_2 SO_4 Heavy	.24	.19	.21	.27	.20	.23	.28	.22	.25	.26	.20	.23

The average shoots of the three lengths between 5 and 20 centimeters are consistent in the nature and degree of their variation in diameter from the check.

Where sodium nitrate had been used alone the shoots were considerably larger at the base and at both the leaf and flower buds than the shoots of the check tree.

On the other hand, where potassium sulphate was used in addition to sodium nitrate the shoot diameter at the base and at the flower and leaf buds was much smaller than where sodium

nitrate was used alone. This relatively small size was produced whether the amount of the two fertilizers was large or small. The diameter was, in fact, the same as the diameter of the check shoots of equal length, that is, as small as if no fertilizer had been used at all.

The average diameter of the shoots was less at the flower buds than at the leaf buds regardless of treatment. This is doubtless due to the formation of flower buds nearer the distal ends of the shoots.

Frequencies of Flowers on Shoots of Various Lengths

Although shoots up to one centimeter in length bore almost no flowers, the shoots between one and five centimeters bore, in all cases, the greatest number of flowers per centimeter of shoots. The high production of flowers on these shoots and the rapid decrease in flowering properties relative to length on longer shoots are shown in the following table:

TABLE II.

Flowers per Centimeter on Shoots of Different Lengths (centimeters.)

Treatment	1-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40
Check	.17	.11	.05	.08	.13	.07	...	...
$NaNO_3$ light	.38	.11	.11	...	...	.04	...	.06
$NaNO_3$ K_2SO_4 Light	.60	.37	.23	.17	.24	.19	.17	.10
$NaNO_3$ Heavy	.49	.45	.27	.20	...	...	...	.13
$NaNO_3$ K_2SO_4 Heavy	.69	.34	.25	.11	.21	.10	.07	.09

That such short shoots (between 2/5 of an inch and 2½ inches) are so productive is perhaps surprising. It is apparent that the behavior of these short shoots is an important factor in fruitfulness. Their numerical proportion relative to shoots of other lengths and their total number will be considered later in this paper.

The production of flowers on shoots of various lengths as influenced by sodium nitrate alone and sodium nitrate with potassium sulphate, is also indicated in Table 2. It will be seen that the tree fertilized with a light application of sodium nitrate produced hardly any more flowers than the unfertilized tree, and that the shortest shoots alone were affected. The remaining three trees (treated with a light application of sodium nitrate and potassium sulphate, a heavy application of sodium sulphate, and a heavy application of sodium nitrate and potassium sulphate) seem to have behaved alike. The floral productiveness of shoots of all lengths was much above that of the check, and by about the same amount in all three cases.

It seems desirable to translate the figures given in Table 2 into the number of flowers per shoot of the various lengths instead of the number of flowers per centimeter.
These figures are given in Table 3.

TABLE III.

Flowers per Shoot on Shoots of Different lengths (centimeter).

Treatment	1-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40
Check	0.5	0.8	0.6	1.4	2.3	1.9	...	...
$NaNO_3$ light	1.0	0.8	0.7	...	...	1.0	...	2.6
$NaNO_3$ K_2SO_4	1.3	2.7	3.0	2.6	5.7	5.0	5.5	3.5
$NaNO_3$ Heavy	1.4	3.3	3.2	3.7	...	...	...	6.5
$NaNO_3$ K_2SO_4 Heavy	1.9	2.4	2.9	1.9	4.5	2.8	2.3	3.3

Shoots from the last three trees, which, as stated above, behaved somewhat similarly in the formation of flowers, can be considered together in estimating the relation of shoot length to flower formation. The shortest shoots (averaging 2.4 centimeters in length) produced an average of 1.5 flowers per shoot. Shoots 25-30 centimeters long (the exact average was 26.8 cm.) produced an average of 2.6 flowers per shoot. Shoots 35-40 centimeters long (the exact average was 36.2 cm.) produced an average of 4.4 flowers per shoot. The average number of flowers on these longer shoots was, therefore, only a little over twice (2.3) as great as on the shorter ones. The longer shoots were, however, on the average 13 times as long. These long shoots, which were bearing flowers so poorly in proportion to their length, are the "pencil" shoots which on casual observation of the tree seem to constitute the greater part of the new growth. They are the shoots between ten and sixteen inches long.

LOCATION OF FLOWERS ON SHOOTS

Some effect of the fertilizer on the floral productiveness of the various quarters of the shoot was anticipated. An examination of the data showed that the check tree was behaving differently in this respect from the fertilized trees. On this tree flowers were being borne principally on the distal quarters. On the fertilized trees flowers were borne on the other quarters also, although by far the greater proportion of them were still formed toward the distal end of the shoot.

The data for the shoots between one and 15 cm. long are the most consistent. They are summarized in Table 4.

TABLE IV.

Percentage Flowers of Various Quarters of Shoots Between 1-15 Centimeters Long. Distal Quarter is No. 1

Treatment	Quarters of Shoot 1	2	3	4
Check	100	0	0	0
$NaNO_3$ light	73	18	1	9
$NaNO_3$ and K_2SO_4 light	74	23	3	0
$NaNO_3$ heavy	60	19	18	3
$NoNO_3$ and K_2SO_4 heavy	80	16	2	2

Above the length of 15 centimeters flowers were occasionally formed on the proximate three quarters of the shoots of the check.

The greatest difference between the check and the fertilized trees was to be seen, therefore, in the behavior of the short shoots.

Conclusions from Measurements made in the Spring of 1921

The conclusions drawn from the measurements made in the spring of 1921 were, (1) that potassium sulphate was modifying the development as indicated by the small diameters of shoots of trees treated with potassium sulphate in addition to sodium nitrate, as compared with diameters from trees treated with sodium nitrate only; (2) that shoots shorter than one centimeter bore no flowers on the unfertilized tree and very few on the fertilized trees; (3) that, regardless of the fertilizer treatment, shoots from 1 to 5 centimeters long bore more flowers per centimeter than longer shoots; (4) that on the fertilized trees the absolute number of flowers on shoots 24 to 40 centimeters (10 to 16 inches) long, was only a little more than twice that on shoots one to five centimeters (on the average about one inch long;) that is, that they were only about one-sixth as productive in proportion to length; (5) that the light application of sodium nitrate produced only a slight increase in the flowering properties of the shoots; (6) that the light application of sodium nitrate and potassium sulphate, the heavy application of sodium nitrate, and the heavy application of both fertilizers, produced similar and marked results in the production of flowers; (7) that the application of these fertilizers increased the floral productiveness of shoots of all lengths, and that possibly the floral productiveness of short shoots was increased the most; (8) that sodium nitrate alone or with potassium sulphate not only increased the production of flowers on the distal quarters, but induced the formation of flowers on the proximate three quarters of shoots of the shorter lengths.

Total Number of Shoots and Distribution According to Length

It seemed especially desirable after making the above study to determine the effect of sodium nitrate and potassium sulphate, alone and together, upon the total number of shoots formed and upon the distribution of shoots according to length. The measurements made in the fall of 1921 had these objects principally in view.*

In determining shoot formation and length distribution all of the shoots on entire trees were measured in two or three cases; usually, however, all of the shoots on what were estimated as

*It was also thought desirable to determine whether or not potassium sulphate had affected the diameter of the 1921 growth in the same way that it had affected the growth of 1920 when used in addition to sodium nitrate.

To determine the latter point the diameter of all the shoots between 10 and 15 centimeters long on two trees in the potassium sulphate-sodium nitrate plot, and on two trees in the check plot, were measured. The average diameter of the shoots on the potassium sulphate-sodium nitrate plot (0.234 cm.) was, if any difference was shown, smaller than the diameter of the corresponding shoots of the checks (0.246 cm). Further data covering this point will be obtained when the next measurements are made.

carefully as possible to be halves of trees were measured. The numbers of shoots measured in the latter instances were enough to indicate the percentages of the various lengths. The entire number of shoots on some trees was obtained by multiplying the number measured by two.

With the exception of the check trees, measurements were made only on heavily fertilized trees. The treatments given trees on which measurements were made were as follows: (1) unfertilized; (2) fertilized heavily with sodium nitrate; (3) fertilized heavily with sodium nitrate and potassium sulphate; (4) fertilized heavily with potassium sulphate. The trees were all located in the same series of cultivated plats in which the earlier measurements had been made.

The results of the measurments of shoot lengths are summarized in Tables 5 and 6 as follows (for convenience and accuracy a smaller number of groups of the longer lengths is made).

TABLE V.

Percentage of Shoots According to Length on Fertilized and Unfertilized Trees

Treatment		Total Shoots	Percentages of each length						
			Below 1 cm.	1—5 cm.	5—10 cm.	10—20	20—40 cm.	40 cm. and over	Branching primaries
Check		3472	43	25	12	9	8	3	2
		4472	44	25	12	7	5	4	2
	Average	3972	43	25	12	8	7	3	2
$NaNo_3$		2842	28	38	15	10	6	3	1
Heavy		3452	36	32	12	8	7	3	1
	Average	3069	32	35	13	9	7	3	1
$NaNO_3$		3201	31	33	12	11	8	3	2
K_2SO_4		3264	29	35	12	9	7	4	2
Heavy									
	Average	3232	30	34	12	10	8	3	2
K_2SO_4		2298	28	32	14	12	8	4	2
Heavy		2161	24	32	16	14	8	3	2
	Average	2228	26	32	15	13	8	3	2

Members of each pair of trees behaved sufficiently alike to indicate the validity of the following conclusions:

The trees fertilized with potassium sulphate in addition to sodium nitrate were behaving like those fertilized with sodium nitrate alone in the total number of shoots formed and in their proportioning according to length.

There was a great difference in this respect between the trees treated with sodium nitrate, or sodium nitrate and potassium sulphate, and the check trees. The total number of shoots on the checks was much the higher; there was a relatively high percentage of shoots less than one centimeter long; and the percentage of

shoots from one to five centimeters long was low. However, the check trees and fertilized trees were much alike in the distribution of shoots above five centimeters in length.

The trees treated with potassium sulphate alone did not behave like any of the others, in that the total number of shoots formed was much smaller. The distribution of shoots among the various lengths was, as far as could be told, about the same as the distribution on the trees treated with sodium nitrate and potassium sulphate. If there was any difference in distribution, it was that on the trees treated with potassium sulphate alone the proportion of long shoots was higher. The writer is not inclined to attribute the pecularity in shoot growth shown by the trees of this plat directly to potassium sulphate without further evidence; bacterial shot-hole was severely defoliating all the trees of the plot at the time the record was taken. Defoliation of the trees measured on other plots was slight and appeared to be uniform in amount.

The total number of shoots of the various lengths is possibly more significant than their distribution. Data covering this point are presented in Table 6.

TABLE VI.

Number of Shoots of Various Lengths on Fertilized and Unfertilized Trees (averages).

Treatment	Total Shoots	Below 1 cm.	1—5 cm.	5—10 cm.	10—20 cm	20—40 cm.
Check	3972	1708	993	476	318	278
$NaNO_3$ Heavy	3069	982	1104	399	276	215
$NaNO_3$ and K_2SO_4 Heavy	3232	970	1099	388	323	259
K_2SO_4 Heavy	2228	579	713	334	290	178

Table 6 shows that although there was a great difference between the checks and the fertilized trees in the distribution of shoots less than five centimeters long, the total number of shoots having a length above one centimeter was about the same on all the trees, with the exception of those fertilized with potassium sulphate alone.

CONCLUSIONS FROM MEASUREMENTS MADE IN THE FALL OF 1921.

The conclusions from the measurements of September 1921 are; (1) that the total number of shoots on the trees fertilized with sodium nitrate, or potassium sulphate and sodium nitrate (both applied to the soil in much larger amounts than are usually applied in orchard fertilization), produced fewer shoots than the checks, the difference being in the number of extremely short shoots of unproductive length; (2) that the above two treatments practically every year.

produced about equal numbers of shoots of the various lengths; (3) that trees fertilized with potassium sulphate alone produced still fewer shoots (on this plat bacterial shot hole may have been a disturbing factor); (4) that trees fertilized with both potassium sulphate and sodium nitrate produced shoots having as small diameters relative to their lengths as the shoots of unfertilized trees.

General Conclusion from Spring and Fall Measurements

It is evident, therefore, that the difference between the total floral productiveness of unfertilized trees and trees fertilized with sodium nitrate, or sodium nitrate and potassium sulphate, was not to be attributed, to any extent, to a greater number of shoots of productive lengths, or to an increase in the length of the shoots. The effect of these treatments seems to have been rather to prevent the formation of unproductive shoots, less than one centimeter in length, and to increase the productiveness of those of a length greater than one centimeter.

Potassium sulphate which, as other observations are showing, affects the yield and the production of flowers and alters the character of the shoot growth as indicated by the diameter.

It was found that shoots less than one centimeter long are unproductive. Above this length the short shoots produce many more flowers, in proportion to their length, than the long shoots.

Observations on Hardiness in the Colder Parts of Canada

By W. T. Macoun, *Central Experimental Farm, Ottawa, Canada.*

HARDINESS has been aptly called "The Jewel of the North" by one of the members of the Great Plains Section of the American Society for Horticultural Science. It is the most valuable characteristic that any plant can have in the colder parts of America, and the first question which suggests itself when a new plant is introduced, or when some variety of fruit has been mentioned, is—is it hardy?

A hardy plant, as referred to in this paper, is one which, except under very unusual climatic conditions, is not appreciably injured in winter. A half hardy woody plant is one which usually has one-fourth or more of the previous season's growth killed nearly every year, and a half hardy herbaceous plant is a kind of which some specimens are killed occasionally. A tender woody plant is one which kills to the snow-line or to the ground nearly every year, and a tender herbaceous plant is one which winter kills

Herbaceous plants are very susceptible to unusual climatic conditions in late fall and early spring, and the years when there is an exceptional amount of killing among herbaceous plants are more frequent than are those when woody plants are affected.

There have been seven winters from which there has been an unusual amount of injury to woody plants in the Provinces of Ontario and Quebec during the past sixty-three years. These were 1858-9, 1876-7, 1884-5, 1895-6, 1898-9, 1903-4, and 1917-18. Root-killing was the principal form of injury from these winters in three of the seven, namely, in 1884-5, 1895-6, 1898-9. In these winters there was little or not any snow on the ground in the middle of winter.

The most recent winter when injury to herbaceous plants was very great was the winter of 1919-20, when there were greater losses at Ottawa among herbaceous material than there had been in thirty or more years. The injury to woody plants was negiligible that winter. Of the seven winters previously mentioned, when the injury to woody plants was very great, the two most destructive winters in the past thirty years were those of 1903-4 and 1917-18, but, while there was root injury in some places, in most cases it was the branches and trunks which were killed. There was somewhat of a similarity between the winters of 1903-4 and 1917-18 as there were some long spells of cold weather in the month of December. In 1903-4 the temperature was -23.2° F. on December 15; in 1917-18 it was -25° F. on December 12. At Ottawa it was below zero on 58 days in the winter of 1903-4, and on 55 days in the winter of 1917-18.

As hardiness is the first consideration, it is very desirable that all the information which can be brought together, resulting from experiment and research, and from general observation, be made available in order to as speedily as possible materially lessen the great loss there is each year from planting plants which are really not suitable to the climate to which they are to be subjected.

At the Central Experimental Farm, Ottawa, there is a large collection of woody plants in a Botanic Garden, comprising between 2,000 and 3,000 species and varieties which have been obtained from many parts of the world. These have been under the writer's observation for more than twenty-five years. Notes are taken on each specimen each year in regard to the amount of killing back the previous winter and growth for the current season. Our observation has been that certain plants which killed back badly twenty-five years ago kill back still unless the plant has died. Occasionally the injury is not so great, which is due, doubtless, to the wood being better ripened and the winter being more favorable than usual, but in pratically no case has there been a marked increase in hardiness. Following are a few examples furnished by the Botanical Division, which may be given of many. The key of abbreviations will assist the reader to understand the following notes.

Pl.—planted; **h.**—hardy; **k.**—killed; **gr.**—ground; **fg.**—fair growth; **hfg.**—hardy, fair growth; **sg.**—strong growth; **ny**—nearly.

Fraxinus Ornus; pl fall 1889; K ¾ 98; K to near gr fg 99;

K to near gr sg 00; 01; 02; 03; 04; 05; 06; fg 07; K ½ fg 08; 09; 10; 11; 12; 13; K ½ fg 14; 15; 16; K 1/3 fg 17; K to near gr fg 18; K ½ fg 19; K to near gr fg 20; 21.

Acer Negundo crispum; pl 97; ny h fg 98; K 1/3 fg 99; K to near gr fg 00; K to near gr sg 01; K ½ sg 02; K 1/3 fg 03; K ¼ fg 04; K ½ fg 05; K to near gr fg 06; K ½ fg 07; K 1/3 fg 08; K ½ fg 09; K 1 ft fg 10; K ½ fg 12; K 1 ft fg 13; K ¼ fg 14; hfg 15; K 2 ft fg 16; K 1/3 fg; W. K. 18.

Acer Negundo heterophyllum; pl 97; K to near gr fg 98; K 2/3 fg 99; K to near gr 00; K ½ sg 01; K 1/3 sg 02; K ½ sg 03; K 1/3 fg 04; K to near gr fg 05; 06; K ¼ fg 07; K ½ fg 08; K ½ fg 09; K ½ fg 10; K 1 ft fg 12; hfg 13; 14; K at tips fg 15; hfg 16; K 3 ft fg 17; W. K. 18.

Diervilla hortensis venosa; pl fall 89 K to gr 97; K ½ fg 98; K ½ fg 99; K to near gr 00; K ½ fg 01; hfg 02; K to near gr 03; ny h fg 04; ny h sg 05; K 1/5 sg 06; K 1/5 fg 08; K ¾ sg 09; K ¾ sg 10; K ¾ sg 11; K ½ fg 12; ny h fg 13; ny h fg 14; K at tips fg 15; ny h fg 16; K ½ fg 17; K to near gr 18; K at tips fg 19; K to gr fg 20; hfg 21.

Diervilla rosea Desboisii; pl 89; K 1/5 sg 97; K 1/3 sg 98; K to near gr sg 99; K ½ sg 00; K to near gr sg 01; ny h sg 02; K to near gr sg 03; 04; K to near gr sg 05; a few shoots hy h most of 1 K to near gr 06; K to near gr lower shoots ny h sg 07; K 1/3 lower shoots ny h fg 08; K to near gr sg 09; K ½ sg 10; K ½ fg 11; K ½ fg 12; ny h fg 13; ny h fg 14; K at tips fg 15; ny h fg 16; K ½ fg 17; K to near gr sg 18; K 2 ft 19; K to near gr sg 20; hfg 21.

Deutzia hybrida Watereri; pl 99; K to near gr fg 00; K to near gr sg 01; K ¾ sg 02; K to near gr sg 03; 04; K to near gr fg 05; K to gr fg 06; K to near gr fg 07; K ½ fg 08; K to gr sg 09; K ¾ fg 10; K to near gr fg 11; 12; 13; K ½ fg 14; K to near gr fg 15; K ¾ fg 16; 17; K to gr fg 18; 19; 20; K ½ fg 21.

Ligustrum vulgare fr. lutea; pl 97 hfg 98; hfg 99; hfg 00; K 1/3 fg 01; hfg 02; ny h fg 03; K to near gr sg 04; K to near gr sg 05; K at tips ny h fg 06; K to near gr fg 07; K 1 ft fg 08; K to near gr fg 09; K at tips fg 10; K ½ fg 11; K ½ fg 12; ny h fg 13; K 1/5 fg 14; K ¼ fg 15; K ¼ fg 16; 17; K at tips fg 19; K ½ fg 20; hfg 21.

It is interesting to record that a large number of plants are killed to near the ground each year, yet the roots remain alive.

At the Experimental Farm, Ottawa, there is a nursery in which many varieties of fruits are growing each year as one, two, and three year old trees. In northern nurseries, such as that at Ottawa, it is the custom, before the second years's growth commences, to cut back the yearling trees almost to the ground as there is usually more or less winter injury to the wood the first year, the season not being long enough to ensure the wood being ripened sufficiently to withstand the winter. In the season that wood is injured in the nursery there may be no killing back to the same variety in trees that have been planted in the orchard, and seldom to three year old trees in the nursery, the wood of

which ripens sooner than that of the yearling trees in the nursery where cultivation continues rather late in order to get a good growth on the young trees.

After the severe winter of 1917-18, notes were made on 319 lots of three year old apple trees, including 300 varieties, in order to ascertain the amount of killing back. Notes were made on May 30 and 31, 1919, the approximate proportion of the tree which was killed from the tips back being recorded. Practically none of these varieties would have killed back in the nursery after an ordinary winter.

Percentage of Winter Injury to Three Year Old Apple Trees in Nursery.

Killed to near ground,	7.52 per cent.
Killed back 75, three-fourths,	19.12 per cent.
Killed back 66, two-thirds,	3.76 per cent.
Killed back 50, one-half,	17.87 per cent.
Killed back 33, one-third,	13.48 per cent.
Killed back 25, one-quarter,	8.47 per cent.
Tips killed back,	18.81 per cent.
Not killed back,	10.97 per cent.
	100.00 per cent.

Of the varieties which did not kill back at all, 60 per cent were hybrids between crab apples and apples.

The few degrees of frost which are sufficient to cause discoloration in the wood of the tenderer varieties of apples, was well brought out in an inspection of a nursery in British Columbia by the writer in 1912. Out there in some parts there is sometimes as much as fifteen to twenty degrees of frost in the fall while the wood of the trees in the nursery is very unripe and the leaves still green. The following notes were taken on October 24, 1912, on two year old trees in a cellar which had been dug after 13° F. of frost;—

Esopus Spitzenburg—(A rather tender variety): 10 trees—all showed discoloration just below the cambium within a foot from the ground, and one showed a slight bursting of the bark.

Yellow Newtown—(A rather tender variety): 10 trees—all showed discoloration from ground to one foot above.

Northern Spy—(One of the hardiest winter sorts, but not recognized as a very hardy variety): 10 trees—nine had no discoloration; one showed slight discoloration.

Wealthy—(A hardy variety): 10 trees—none showed discoloration.

McIntosh—(A hardy variety): 10 trees—nine had no discoloration; one had slight discoloration and the bark raised a little.

From observation we should say that the hardiest varieties of a certain kind of fruit, as, for instance, the apple, lose their leaves earliest, indicating a more thorough ripening of the wood than the tenderer sorts, the leaves of which remain on the trees until the last, indicating late growth. No doubt laboratory investigations will show whether, if these sorts which are tender in the North were grown under optimum conditions for ripening

wood, they would stand as much frost or as sudden freezing as the hardiest varieties.

That there is usually a correlation between early maturity of fruit and hardiness seemed to be well brought out after the very severe winter of 1903-04, when at Ottawa trees of 164 varieties were winter-killed, and of these 130, or 79 per cent, were early winter and winter sorts, while the season of but 21 per cent of those killed were summer and autumn. The varieties recognized by fruit growers as being the hardiest varieties grown in America are all summer and autumn sorts. They are Hibernal, Oldenburg, Patten Greening, Antonovka, and Charlamoff. But there are some early sorts that are not hardy where most are, and the most outstanding one is the Gravenstein, which is among the tenderest.

Hardiness of Stocks of Great Economic Importance in Canada

Our observations have convinced us of the importance of having wood well ripened if a tree or shrub is to stand the best chance of coming through a severe winter uninjured, but well ripened wood will be of no avail if the roots of the stocks on which plants are propagated are not hardy. The quince kills out root and branch at Ottawa, hence if dwarf pears, which are propagated on quince, are planted there, they will soon die because the roots will be killed. The Americana and nigra plums are the most reliable for planting in the colder parts of Canada, yet, if these are budded on the peach, as they have been by some of the more southern nurseries, and planted at Ottawa, it will not be long before the very hardy Americana and nigra plum trees will be dead. Even the much used Myrobalan plum stock, Prunas cerasifera, is not hardy enough for the north, and the mahaleb stock, Prunus mahaleb, used for cherries, is also too tender.

Lilacs have been propagated on the privet by nurserymen, a popular species being apparently the Californian privet, Ligustrum ovalifolium, which kills out at Ottawa, and it is not long before a hardy shrub like the Lilac is dead.

And in the colder parts of Canada, especially where, even though it be but occasionally, there is no snow on the ground during very cold weather, the apple stocks do not furnish hardy enough roots, and in winters when low temperatures come early before the ground is covered with snow, trees on light soils where frost penetrates rapidly are likely to die from root killing. There was good evidence of this in the winter of 1919-20, when there was practically no apparent injury to trees above ground but where a block of 164 trees of Oldenburg, Wealthy and McIntosh normally hardy, were root killed. These trees had been obtained from a Canadian nurseryman, who, it is understood, uses imported stocks. In the Experimental Farm orchard and nursery, where trees had been propagated on crab apple seedling stocks, there was no apparent root killing. It has been the practice to use crab apple stocks for the past twenty-three years at Ottawa, and during that time there has been no appreciable root killing of trees propagated on this stock.

In parts of Canada where the winters are only moderately cold as compared with other places, but where a covering of snow is uncertain, some species of herbaceous plants are winter-killed, while in other places where the temperature in winter is much lower, but where snow usually comes earlier and usually remains during the cold weather, they are only killed when conditions resemble somewhat those in the milder climate. An example of this is the Japanese Anemone, Anemone japonica. In the vicinity of Toronto this usually winter kills. At Ottawa it is usually hardy. In the autumn of 1919 the ground at Ottawa was frozen for a long time before it was covered with snow and the temperatures were low. Anemone japonica which had not been killed at Ottawa in the previous twenty-five years, was killed that winter. Another example of herbaceous plants may be given. Most species of narcissus are hardy at Ottawa, but none are hardy in the treeless parts of the Canadian prairies. In the winter of 1919-20 bulbs of all species of narcissus were killed at Ottawa except where they had been covered with leaves before the low temperatures came. Bulbs had not been killed at Ottawa in the previous twenty-five years.

There was not enough snow on the ground to prevent deep freezing at Ottawa until January 13, 1920, and most of the time up to that date the soil was quite bare, the temperature falling to below zero F. on eighteen days. The first drop to below zero was on December 3rd, when it was -13° F., and the lowest temperature before there was a good snow covering was on December 18th and 19th, when it was -16° F. on both days.

It is for those who have made laboratory investigations to say how and why plants are killed by frost. There seem to the observer to be so many things involved when all kinds of cases are considered that an observer hesitates to make positive statements, but some of the important factors that hardiness and frost injury are dependent on are evidently moisture content of the plant affected or concentration of the sap; moisture content of the soil, which may be too dry or too wet; rapidity of freezing and thawing; and intensity of frost.

From a practical standpoint the horticulturist desires the plant which will withstand the most adverse conditions of climate in the part of the world in which he lives, hence the breeding of new forms through the use of native plants, and plants from parts of the world where the climate is as near like his as is possible to find, would seem to offer the most practical solution to the problem of hardiness. The seasons vary so much that methods of cultivation are not sufficient to save plants from injury in very adverse seasons, though they have some effect.

Relationship of Water-Retaining Capacity to Hardiness

By J. T. Rosa Jr., *University of Missouri, Columbia, Mo.*

A critical survey of the literature indicates that the various theories which have been advanced to explain the killing of plants by freezing, are all associated with the withdrawal of water from the cell. This suggests that factors affecting cellular water loss may explain the differential killing of plant tissues by cold.

If the death of plant cells by cold is due primarily to water-withdrawal beyond a certain point, then the difference between hardy and tender plants may be ascribed to the relative water-retaining power of the cells in the two types of tissue, as well as to the ability of the protoplasm to withstand the lethal changes brought about by water loss.

To test the foregoing hypothesis, a series of experiments have been carried out with vegetable plants, using the cabbage as the principal representative of that type of plants capable of considerable hardening to cold, and the tomato, representing the group not susceptible of much hardening. The experimental data obtained support the hypothesis arrived at from theoretical considerations. The questions whose solution has been sought are: (1) Do cells of hardy plants actually retain more water when frozen than cells of tender plants? (2) Is cold resistance proportional to the water retaining power of the plant cells? (3) Do tender plants exposed to hardening treatments acquire an increased water retaining power, and if so, how is this power acquired—what changes in the living plant are concerned therein?

Early investigators showed that on freezing plants, water is drawn from the cells, ice forming in the intercellular spaces. Some plants are killed once this occurs, others withstand some ice formation but are killed at lower temperatures. Muller Thurgau showed, by measuring the latent heat of ice in frozen tissues, that by no means all of the water freezes at low temperatures. In the work reported here, the dilatometer has been employed to measure the amount of water freezing in leaves, essentially as described by Bouyoucos, and by McCool and Millar. Cabbage leaves of varying degress of hardiness were used in most of the experiments. In a comparison of coldframe hardened and tender green house plants, it was found that a smaller percentage of the moisture froze in hardy than in tender leaves. The same is true of plants hardened by witholding water and by watering with salt solutions. As the temperature is lowered from -3 to -6° C., there is a progressive increase in the per cent of the total water content frozen, but the increase rapidly becomes less and less for each degree of temperature lowering. In fact, the per cent of water remaining unfrozen is approximately a logarithmic function of the temperature.

Likewise, the actual amount of water remaining unfrozen in hardy leaves is much greater than in tender leaves though the initial moisture conten of the hardy leaves is the smaller. Thus, calculated on the basis of 100 grams of fresh tissue, in hardened leaves 60 grams remain unfrozen at -3°C., 43 grams at -4°C., 35 grams at -5°C., and 30.4 grams at -6°C.; in 100 grams of tender leaves, the unfrozen water at the corresponding temperatures was 35, 22, 16 and 14 grams respectively.

Since the percentage of the total moisture which freezes at each temperature is much less in hardy than in tender plants, and the actual amount of water remaining unfrozen is much greater in the former, we may conclude that the cells of hardy tissue do possess a greater power to retain water when exposed to freezing. Whatever the nature of the water-retaining force, it is overcome in successively smaller increments by the force of crystallization as the temperature is lowered.

In another group of experiments, changes in water-retaining capacity were studied in cabbage plants exposed to hardening in the coldframe for varying periods. The percentage of water frozen at -5°C. decreased rapidly the first four days the plants were exposed and more slowly for 16 days thereafter. As the hardening process advanced, there was a corresponding increase in the amount of water remaining unfrozen at -5°C., thus furnishing direct evidence as to the connection of water-retaining power and hardiness.

In dilatometer determinations during the summer, it was found that more water froze in leaves of tomato and sweet potato, than in leaves of cauliflower growing under similar conditions. This indicates that the difference in response to low temperature between species may be of the same nature as the difference between hardened and tender tissue of the same species. However, it does not necessarily follow that there is a definite minimum moisture content below which protoplasm of all plants dies. Among other things, the ability of protoplasm to survive water loss, as well as the power of the cell to prevent it, depends upon the state of physiological activity. Hardened plants, while not necessarily dormant, are growing slowly, and hence are not very active physiologically. This may explain why all treatments checking the growth of plants has increased their hardiness, as shown by numerous investigations. The hardening process in vegetable plants, autumnal changes in evergreens, the maturing process in woody stems, and the ripening of seeds, may involve changes which increase the stability of the potoplasmic structure as well as changes which make for increased water-retaining power.

Further evidence of increased water-retaining power in hardened plants was derived from a study of the relative transpiration rates of hardy and tender cabbage plants. It is a common observation that unhardened plants wilt more severely upon transplanting to the field than do properly hardened plants. In fact, the ability of hardened plants to withstand transplanting without dangerous wilting is generally more important to the practical grower than the increased cold-resistance developed

by the hardening process. In one experiment under low transpiration conditions, the water loss is grams per square meter per hour for tender plants was 54.4; for dry-grown greenhouse plants, 48.5; for plants hardened in coldframe 5 days, 41.5. In another experiment under high transpiration conditions, the water loss in grams per square meter per hour for tender plants was 194; for coldframe hardened plants, 136; for plants hardened by watering with $\frac{M}{10}$ NaCL, 137. The difference in water loss from the plant as a whole was in every case much greater than the transpiration rate would indicate because the hardened plants always had the smaller leaf area. That hardened plants have a lower transpiration rate is significant, for it indicates a greater power to hold water. However, such water-retaining power might be due to the development of xerophytic characters in general and not to any special cellular water-retaining power. That something of this sort takes place in the tomato is indicated by the fact that hardening treatments do not greatly increase the cold resistance, but do enable the plant to withstand transplanting easily.

Another method of determining water retaining power, measuring the rate of drying in an oven, has been used here by Mr. V. R. Boswell. His results show that water is removed by this method most rapidly from tender tomato leaves, but leaves from tomato plants exposed to hardening treatments lost water nearly as fast. Tender cabbage lost water more slowly than did tomato leaves, and hardened cabbage lost water still more slowly.

From the foregoing discussion it apears conclusive that hardiness and high water-retaining power are closely associated. Some attention has been given to the probable cause of this increased water-retaining power. Two factors accompanying the hardening process—increased percentage of dry matter and increased sugar content, are also recognized as generally accompanying the state of being hardy. Such changes, however, are usually not great enough to account for much increase in water-retaining power. The work of Spoehr on cacti and the well known water-holding power of such materials caused particular attention to be directed to the pentosan content of hardened plants. It was found that the total pentosan content of plants increased markedly when growth was checked by any treatment. In cabbage, the rate of increase in pentosan content closely parallelled the gain in water-retaining power. Still more striking differences were found in the hot water soluble fraction of the pentosan content. This fraction is thought to represent approximately that portion of the pentosans occurring in the colloidal cytoplasm, and therefore most likely to affect water retaining power directly. In tomato and sweet potato, the hot water soluble fraction is low in tender plants and remains low when the plants are exposed to hardening treatments. On the other hand, cabbage, kale and celery had a rather low soluble pentosan content when in the tender condition, but upon hardening this was found to increase rapidly. In fact, with these plants, most of the increase in total pentosans in hardened plants was due to the increase in the soluble fraction. The marked parallelism of pentosan content, especially the hot water

soluble fraction to water-retaining power and hardiness, indicates a causal relationship. However, pentosan content alone should not be taken as an absolute index of cold resistance, since the functioning of such materials as water retaining substances in the cell may be affected by many other factors.

In conclusion, it may be said that the hardening process in plants is accompanied by a marked increase in water-retaining power, which is considered to be due chiefly to the imbibitional forces of the cells. The increased water retaining power is believed to be the direct cause of the cold-resistance of hardy plants—upon freezing, the cells of such plants retain a large proportion of their moisture content in the unfrozen condition.

The differential reactions, when subjected to hardening treatments, of plants possessing potential hardiness (as the cabbage) and of plants lacking it (as the tomato), indicate that the fundamental difference between hardy and tender species lies in their ability to initiate changes whereby the stability of the protoplasm and the water-retaining power of the cell are increased. Hardy species possess the ability to initiate such changes to a great degree, while tender species possess it only to a slight degree, or not at all.

Chemical and Physiological Studies on Fruit Storage

By J. R. Magness, *The Marble Laboratory, Inc., Canton, Pa.*

It is not the purpose of this discussion to deal with completed research on fruit in storage, so much as to present a discussion of some of the work under way at the Marble Laboratory, Inc., in order that the scientific horticulturists of the country may know of this new endeavor, and in order that we may gain the benefit of your discussion and suggestion.

It is not necessary in presenting such a topic before this association to discuss in detail the tremendous importance of a better knowledge of what takes place inside the fruit following its removal from the tree or vine, and before it reaches the ultimate consumer. A comparatively small percentage of the total fruit crop of the country moves directly into consumption following its removal from the tree. Much of the fruit is transported long distances by rail or boat, and held in common or artificial cold storage many weeks or months before finally reaching the consuming public.

A great deal of work has been done on the proper handling of fruits and vegetables in storage, both by the Federal Department of Agriculture, and by the different experiment stations. The results of many of these investigations have been checked by commercial practice, until a possible storage season seems fairly well established for many fruits. The season for handling apples, pears, Vinifera grapes, and numerous other fruits, has been greatly prolonged by storage.

In very much of the work that has been done, however, the quality of the product at the end of the storage season has not been studied with the same degree of interest that has been shown in determining the best methods of keeping the fruit intact and of good appearance. It is common knowledge that fruit in general does not possess the high flavor and aroma that is normal for any particular kind, following a long season in storage. Although apples can be held in storage until the new crop comes on, it is unusual to buy a really high class fruit on the market later than March or April. Yet this is the season when consumption would be at its highest, provided really high quality fruit was being supplied.

The Marble Laboratory, Inc., has been organized for the purpose of making a careful chemical and physiological study of the life conditions of fruit in storage. Although supported entirely by private capital, the results of all the investigations carried on are to be made public as soon as they appear conclusive. It is hoped that the results of these investigations will be of general interest to the fruit industry.

During the remainder of the time alloted to me, I wish to discuss something of the equipment of the Marble Laboratory, together with a mention of the work under way at the present time.

This Laboratory is located near Canton, in North Central Pennsylvania. The property of the incorporated laboratory includes some 100 acres of farm land and general farm buildings and between 60 and 70 acres of apples which are now just coming into full bearing. Consequently there are most excellent facilities for correlating orchard erperiments and practice with apple storage work.

The fruit storage equipment consists of a large earth bank type storage cellar, of 10,000 bushels capacity, three refrigerated boxes, and one room maintained at a constant temperature of 60 to 70°. The earth cellar and two of the refrigerated rooms are equipped for complete and thorough ventilation with outside air, and with humidity controls. The third room has no provision for ventilation, though as the door is opened at rather frequent intervals, much more fresh air is admitted than is the case in many of the large commercial cold storage plants.

In connection with this equipment for controlling temperature, humidity and ventilation, a complete chemical and physiological laboratory has been provided for the purpose of studying the life processes of the fruit under the different environmental conditions.

During this first season of active experimental work, apples are being held in the cellar whose temperature and humidity are practically those of the earth, although fresh outside air is circulated through by means of fans. Fruit is also being held in each of the three cold storage rooms. One of these rooms is held at 32°, with no more ventilation than is necessitated by going in and out of the room. The second is held at 35°, and ventilated by fans at the rate of four air changes per hour, while the third room is held at 32° and ventilated at the same rate as the 35° room.

Fruit for the experiments has been secured from districts in

which the different varieties are leaders. Thus Yellow Newton and Esopus Spitzenburg apples were shipped from Hood River, Oregon; Jonathan, Delicious, Rome Beauty and Winesap from Wenatchee, Washington; Northern Spy and Baldwin from Western New York; York Imperial from State College Pennsylvania; and Wealthy from the laboratory orchard. All fruit was shipped to Canton via express and immediately after arrival was repacked into various containers, as follows: Ventilated crates, unwrapped; western boxes unwrapped; western boxes wrapped in oil paper; western boxes, wrapped in ordinary paper. In addition, the York Imperial, Northern Spy, and Baldwin were stored in barrels.

In repacking, care was taken to place an equal number of apples from each of the original containers in each new package. Fruit of each variety in all the different packages was immediately placed in storage.

A number of tests and analyses are being made to determine the condition of the fruit in storage. At intervals of about six weeks, uniform fruit from each type of package, and of all the varieties under the different conditions of storage, are subjected to a "pressure test". A machine of the type devised at the Oregon Experiment Station is used, which gives an accurate measure of the pounds of pressure that are required to make an indention of a certain size in the fruit. Although considerable variation occurs in various individual fruits, and even in different parts of the same fruit, it has been found that the softening of the fruit from month to month of the storage season can be readily measured by this means. Somewhat more regular and consistent results have been obtained by removing the peel before testing than by testing the unpared fruit. By this test, it is hoped that we will be able to secure a definite record of the influence of temperature and ventilation as well as type of package, upon the rate of softening of the fruit in storage.

All ten varieties are being tested in this way, as well as by gross observation. It is planned to make detailed records of flavor and texture, and particularly of the amount of scald present in all fruit at the end of the storage season for the different varieties.

In outlining the work, it was at once seen that not more than two varieties of fruit could be used in the detailed chemical and physiological tests. Consequently Baldwin and Winesap, two long keeping varieties, important in the eastern and the western states respectively, were chosen for this work. The studies being carried on under these heads may be outlined as follows:

Chemical. Samples of the fruit of these two varieties were taken immediately after the fruit arrived at the laboratory. Then at intervals of six weeks to two months, further samples are taken of these varieties under all the different storage conditions. These analyses are to include only acids, pectin materials, and sugars. Sugars and acids are intimately linked with fruit flavor, while it has been thought that pectin material may be intimately linked with the hardness of the fruit as shown by the pressure tests.

Respiration. The carbon dioxide output of these two varieties is being measured under all the different storage conditions, and at

various intervals in the life of the fruit. The fruit is removed from its package and placed in desiccators at the same temperature at which it had been held in storage. After two to three weeks at the temperature under which the fruit has been held since the time of storage, the same fruit is transferred to a constant temperature room maintained by electric heat automatically controlled at about 62° F. Here the respiration of the fruit is measured for a further two weeks period. At intervals of two months, further series are started in the cold storage rooms. It is planned to make four complete series of the respiration tests.

In connection with the respiration work, catalase is also being measured in the tissues of the fruit. It is quite apparent in the results so far attained that there is an association between the amount of catalase and the respiratory rate, but we have no evidence that the relationship is more than an association.

Also in connection with this general study, the composition of the air of the inter-cellular spaces of the apple tissue is being determined. It has been found that there is a wide variation in the CO_2-O_2 ratio within the tissues, depending upon the temperature at which the fruit is held. It is known that in certain fruits, as Bartlett pears, there is considerable variation in the ripening process, aside from rate, depending upon whether it is carried on at high or low temperatures. It is probably that the CO_2-O_2 pressures inside the fruit are relatively much more important than those outside in determining what is going on inside the fruit.

Odorous Constituents. Of tremendous importance in determining that rather indefinable something known as quality in fruit is the odor. Much of our reaction of pleasure or dislike upon biting into an apple, is its effect upon our sense of smell. Certainly one reason for the poor quality and flat taste of much of our cold storage fruit is the lack of odor when the fruit is removed from storage.

During the period when the fruit is under test for carbon dioxide output in the 62° room, following the removal from cold storage, the volatile odorous substances are being collected. According to the work of Powers and Chesnut, these substances consist mainly of esters of amyl alcohol with formic, acetic, caproic and caprilic acids. Although these workers did not take the natural emanations from the fruit, it is highly probable that the odorous constituents consist of volatile acids and esters. These are collected in the bubbling tubes of potassium hydroxide used in absorbing the CO_2 of the respiration tests. It is later separated from the caustic and the total volatile, and measured as a measure of the odorous constituents.

From the rather hurried outline of the work as projected and now under way, it will be seen that we are attempting a rather comprehensive study of the life conditions of the apple in storage. If through properly controlled ventilation and humidity, in conjunction with temperature, it is possible to prolong the season when stored fruit is of really high quality and flavor, we hope to discover the way to do it. In any case, The Marble Laboratory, Inc., hopes to make some contribution toward the immensely important subject of the preservation of fruit through storage.

Hardiness From the Horticultural Point of View*

By M. J. DORSEY, Experiment Station, Morgantown, W. Va.

THE division line between the eastern horticulture and that of the upper midwest may be roughly drawn in a southwesterly direction through Minnesota. This is a region which is, relatively speaking, just finding its fruit varieties. In this borderland new varieties and new introductions are being tested continually. After watching the survival value of many different forms under Minnesota conditions for a period of ten years, it became clear that much of the loss could be avoided by recognizing some inherent characteristics of species and varieties.

Let us look at the problem first then from the standpoint of the species. One of the outstanding features of the American fruit list is that the most important varieties for many sections of the country have been introduced. This was especially true at an earlier day. Consider in this connection the apple, peach, pear, grape, cherry, quince, all the fruits of other countries. Introductions were made for the most part not as species but as varieties. What are the limitations of the variety then as compared with the species?

In the summer of 1916, at fruiting time, the writer made a survey of the wild red raspberry (Rubus strigosus) in three general regions in Manitoba. Open pollinated seed was collected from plants bearing the best fruit. Collections were made 60 miles east of Winnipeg along the Pinnewa River, next north on Lake Winnipeg at Little Bull Head and Big Bull Head on the west shore, and still farther north 250 miles or so from Winnipeg on the Big George Island. The last collections were made in the region of the Riding Mountains 150 to 200 miles northwest of Winnipeg. *R. strigosus* grows profusely in many places in this region and is more or less isolated especially in the north and west from other species with which it will hybridize. It should be kept in mind that the seed obtained was open pollinated, and that the collections were made at random over relatively wide spread areas at each collecting point, with the object of getting samples of the species for still more detailed study when the plants were grown in the test rows.

Plants of the different seed collections have now grown in the test rows at the Fruit Breeding Farm in Minnesota for four seasons, developing the typical matted rows of this species the last three years. Many interesting variations can be found among them. One of the most outstanding characteristics of these seedlings is the difference in the growth habit shown by the plants from the different sources. The habit of growth of the collections made at

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Baudette, Lac du Bonnet, Little Bullhead and Big George Island is tall and spreading. In contrast to these, the plants from farther west in the range of the species at Dauphin and McCreary on the eastern border of the Riding Mountains, and at Erickson on the southern border, were more upright in growth. The following table will illustrate the general growth portions of the plants from the different sources.

TABLE I.

Growth Habit of Rubus Strigosus from Seed Obtained from Different Points in Manitoba.

Source of seed	Average height of row, inches	Average spread of row, inches
Baudette	54	72
Lac du Bonnet	54	72
Little Bullhead	44	66
Big George Island	48	72
Dauphin	60	48
McCreary	60	48
Erickson	44	36

This difference in the habit of growth has been constant for the last three seasons. The upright habit of the plants from Erickson, has from the first been quite distinct from the spreading habit of the plants from farther east. The spreading habit does not appear to be due necessarily to a tall growth which falls over, because some of the narrower rows are the tallest. There has been no apparent tendency so far for the plants from the different sources to approach a uniform type.

Were it not for the fact that when these seedlings were planted in the test rows the different lots were set without reference to their source, such differences might be ascribed to some factor of the environment. It seems just as logical, however, to consider that such variations in growth habit were brought about by the conditions under which the plants have had to survive, and that they represent distinct regional types within the species.

Upon further study, in addition to the variations noted above which may be termed regional individual plants also show striking differences. Following the winter of 1919-20, when there was extensive killing back generally in these seedlings, an occasional plant in the row from the seed obtained at Baudette grew from the terminal buds. The tips of the canes of all of the other lots were generally killed back severely, the extremes being as much as four feet. Excepting the few hardy plants which were found in the Baudette row there were no significant differences in the winter injury to the plants from the other locations, all appearing to possess a similar degree of hardiness.

In contrast to the killing in 1919-20, 1920-21 was an "open winter", there being no snow protection for a considerable portion of the dormant season. The canes from all sources were killed to the ground by the conditions which prevailed. The killing and drying took place before February. None were killed

outright, however, and all of the rows sent up the characteristic mass of new plants. Apparently then these plants were brought too far south to be hardy unless protected by the usual snow covering since the native plants of the same species were only killed back a few inches at the tips of the canes. This killing was hardly to be expected in view of the early maturity in the fall.

Let us contrast the response of these seedlings to winter conditions at the Fruit Breeding Farm, with some oak seedlings (*Quercus rubra*) grown at the Forestry School at Itasca Park by J. P. Wentling of the Department of Forestry of the University of Minnesota. In this experiment acorns were obtained from Clarion County, Pennsylvania, University Farm, and from trees native to Itasca Park. The first year after planting all of these seedlings made a good growth. During the following winter those from Pennsylvania were killed outright, top and roots, those from University Farm were killed back to the snow line while those from Itasca Park were not injured at all.

In view of the general trend of these tests it is interesting to note that Herbert (*R. strigosus*), one of the hardiest varieties of the red raspberry in Minnesota and Manitoba which has its origin at Ottawa, winter kills as far south as Washington, D. C. On the other hand, Cuthbert which originated in New York City is one of the tenderest varieties in Minnesota and Manitoba. Again, two rows of self pollinated seedlings of Gregg raspberry were planted adjacent to the Canadian seedling. In May, 1920, the killing records were taken after the plants had been pruned. Twelve were killed outright, 33 were killed to the ground, 17 were killed back half way and 55 were growing at the last buds left after the pruning. The differential killing found here is comparable to that found in the seedlings from Baudette.

When the Canadian seedlings are studied for other characters than hardiness, many different types are encountered. Some canes are glabrous while others show every gradation up to being densely spined. In some cases the spines are green when young while others at the same stage of development are dark red in color. The size of the berries and the number of druplets in each is different and characteristic for practically each plant. The berries borne by some plants are firmer or darker in color than those borne by others. Just before bloom there are interesting contrasts in the general appearance of the buds on canes varying in spineness. More vigorous hills with strong thick canes appear here and there in the rows of each lot. Contrasted with the standard varieties the Canadian seedlings are profuse plant makers. Other differences might be mentioned, but these will suffice to show that there are variations which may be singled out and named as distinct varieties.

Three things can now be emphasized in connection with the species; First, there are distinct regional types; second, there are individual variations; and third; plants from the northern and southern part of the range of distribution may vary greatly in hardiness.

Let us now look at hardiness from the standpoint of the

variety. Using the red raspberry again for the illustration it will be clear that there are types which can be singled out and given a variety name. A fruit breeder would quickly recognize the economic value of a seedling with a vigorous, smooth cane, large firm fruit and upright habit of growth, in contrast to another plant in the same lot with less vigor, densely spined canes and bearing small, soft, light red berries. Suppose one of the better types were named, propagated, distributed and grown. According to the evidence above in Manitoba it would be hardy and, in Minnesota or Missouri tender. On the other hand suppose one of the oak seedling from Pennsylvania were named, propogated, distributed and grown. It would be hardy in Pennsylvania, but would winter kill in Minnesota. Again, the reverse would be the case if one of the seedlings from Itasca Park were distributed southward. Recall the difference in adaptation between Herbert and Cuthbert at this point. It will be seen then that the variety may have some definite limitations as to plant characters, or hardiness, when compared with the species.

We are now in a position to consider hardiness still further in relation to the variety and species. The terms propagation and distribution were used above. When a new variety is found or developed it may be propagated vegetatively almost indefinitely. All new individuals obtained in this way are direct genetic descendents of the original individual, excepting of course bud variations or mutations. Following the usual horticultural practice a single variety may be propagated and distributed over a greater range than the species to which it belongs. Note the Concord grape. *Vitis labrusca* is native to a narrow territory along the Atlantic coast from Maine to North Carolina, yet Concord, one of its varieties, is grown widely over the northeastern half of the United States including many points bordering in Canada. On the other hand, some varieties such as Catawba are much more local in their requirements Certain varieties therefore appear to embody the range of adaptability of the species to a far greater extent than others.

The introduced varieties are even farther removed from the area of the natural distribution of the species. The whole tendency has been in horticulture to distribute the variety wider and wider and by trial and error—mostly error—to eventually determine after years of expensive experiments those regions where it may be profitably grown, most years. A test winter like 1917-18 demonstrated that with some fruits, as with the peach, that the industry may be based upon semi-hardy varieties over a large part of the productive area. It appears, therefore, that the variety, representing as it may a limited genetic combination compared with the entire range of the species, has no means of adapting itself north and south by means of the elimination of the tenderer individuals and surviving by means of the more resistant as does the species.

In addition to the conception of the clone in relation to the hardiness of a variety, versus that of the species, the perennial habit should also be considered. This brings up the whole ques-

tion of nutrition, protection, dormancy, maturity and the rest period, as well as the bearing of the weather conditions upon all of these. For instance, the wide spread injury of the winter of 1917-18 appears to have been preceded generally by a late season. Plums bloomed in Minnesota in the spring of 1917 a month later than the earliest recorded bloom. Since it is necessary for the tree fruits to stand in place, more or less exposed, year after year, it should be clearly recognized that all cultural practices, those relating to growth as well as protection, can control winter killing only within certain limits. By properly regulating culture, varieties on the border of the zone within which they are semi-hardy, may be carried through the dormant season without sufficient injury to prevent the production of fruit.

As contrasted with the species then, the variety may be looked upon as representing only one of the many possible types, or genetic combinations. By means of the usual horticultural practice, with this limitation, the variety can be distributed even more widely than the species which is certain to bring up the question of adaptation seriously in many regions.

We are now in a position to consider the reaction of the individual plant to its environment. We have seen that the individuals of the species may vary markedly as to hardiness from different regions in the native range and that the variety, or clone, being a relatively fixed genetic entity, while generally limited in adaptation, may be planted widely and even exceed the range of the species. In one sense in the variety we are dealing with the relation of a constant to a variable environment, while in the species we are dealing with a variable, or varying individual, in relation to a varying environment.

Keeping in mind then this distinction, when the response of an individual fruit tree or plant is examined critically, it is found that it does not respond the same in all parts. For instance, at the Minnesota Station the wood and cambium of *Amygdalus davidiana* is sufficiently hardy to withstand many winters, but the fruit buds are always killed even by the mildest winters. In the plum, the older wood and bark show more intense browning than twigs. The open winter of 1919-20, was particularly destructive to strawberries. A survey of the Minnetonka region in the spring showed that in some of the strawberry varieties, the older hill plants were completely killed while the runner plants lived to produce fruit. In apple seedlings, the roots are sometimes killed at temperatures which may not injure the top. In some of the plum varieties a larger percentage of the fruit buds may be killed on the older wood than on the terminal one year wood. The reverse appears to be true in both the peach and in some varieties of the plum.

When the fruit bud is examined in detail some parts are found to be injured more than others. In the plum, some of the flowers in a fruit bud may be killed while others are not. Injury may also occur in some tissues of the fruit bud, but not in the fruit bud scales. Further illustrations in the localization of injury could be cited, but these will suffice to show something of the localization of the reaction of the plant to its environment. Such

differences in the individual should be kept in mind in studying adaptation just as clearly as those pointed out above in the variety or species.

It will be seen, therefore, in concluding, that when hardiness is viewed from the standpoint of horticulture, that there are some characteristics inherent in the materials with which we deal which must be taken into consideration in any well planned attempt to determine the suitable varieties for any locality. The failure to do this has been an expensive oversight in many instances in the past, and may be again in the future.

Pruning and Nitrogen Studies in a Devitalized Peach Orchard

By E. C. Auchter, *University of Maryland, College Park, Md.*

IN the spring of 1920, some investigations were started by the Horticultural Department of the Maryland Experiment Station to test the practicability of attempting to rejuvenate a devitalized peach orchard. In addition to using good cultural and spraying methods, a study was made of the effects of different amounts of pruning and of the influence of nitrogen on tree growth.

The orchard selected for the test was ten years old and consisted of ten acres. The varieties were one-third Elberta, one-third Late Crawford and one-third Greensboro, arranged in single rows lengthwise of the orchard. For three years previous to this study, the trees had received practically no pruning, very little spraying, no worming and the soil had not been properly or sufficiently cultivated to keep down grass and weed growth. The trees presented the usual appearance of peach orchards which are neglected in this way. The main limbs, (bare of any fruiting wood), extended up into the air about 16 feet. Scattered over the tops of these limbs were terminal growths of from one-half inch to three inches in length. The majority of the growths on the trees consisted of little more than terminal buds. The orchard was in such poor condition that practically no fruit buds had been formed and the prospects for a crop were very poor. Owners, who happened to have similar orchards in the state, would probably have decided that the orchard was too old and weak to bother with. The result would probably have been its removal.

System of Orchard Management

It is clearly evident that it was necessary to produce new, vigorous wood growth on the trees, if any crop were to be secured. It is a well known fact that middle-aged or weakened peach trees usually respond well to pruning. The exact amount or severity of pruning that would be best to use, of course, varies in each case

with several different factors, such as tree vigor, soil fertility, amount of rainfall, etc. Many trees, quite low in vitality, die, if such drastic measures as dehorning are used. On the other hand, enough new and vigorous growth is not stimulated by a light pruning in many cases. Since there were practically no fruit-buds on the trees, since terminal growths were very short in length and since the trees were in a weakened condition, it was decided to give all of the orchard, except 40 trees reserved for other pruning tests, a moderately severe pruning. The tops of the trees were headed back from four to six feet, which meant that often as much as three and four year old wood was removed. This left the main limbs and side branches from six to eight feet high after the pruning. The main limbs and branches were always headed back to outward growing branches in order to avoid leaving stubs. Certain large limbs were also removed entirely from the trees.

The orchard was given a thorough dormant spraying of con centrated lime-sulphur and summer spraying of self-boiled lime and sulphur.

A pound and a half of nitrate of soda was applied under the spread of the limbs of each tree just as the buds were breaking. The orchard was plowed early in the spring, harrowed every two weeks and finally cover crop seed was sowed during the latter part of the summer. All trees were wormed for bores.

The next spring (1921), the same kind of spraying, fertilizing, worming and soil managing was done. Pruning consisted of thinning out some of the new growths and heading others back moderately. Detailed data concerning the growth and fruit response of these trees during the two years are given in the following tables, which show the results secured in various pruning and nitrogen tests.

Pruning and Fertilizer Tests

The amount and type of pruning which should be given devitalized peach trees, varies with several different factors. Thus the age of the orchard, general vigor of the trees, amount of new growth, prospects for a crop, etc., all influence the kind of pruning that should be done. Some growers, with an orchard similar to the one used in this experiment, would have practiced severe dehorning, others would have pruned moderately, while some, not realizing the importance of pruning, would probably have removed only a small amount of wood. A type of pruning, consisting of a partial or gradual dehorning extending over a three or four year period, has also been advocated by some growers.

In order to get some accurate data regarding the proper amount and type of pruning to give middle-aged devitalized peach trees, 40 trees in the above described orchard were selected for pruning experiments. These trees were not together in a solid block, but were scattered throughout the orchard. It could not be said that any particular soil, moisture or temperature relations, which might occur in certain parts of an orchard, influenced the results. Each tree of the 40 was fertilized in both the years,

1920 and 1921, with one and one-half pounds of nitrate of soda.

The following methods of pruning were used:

1 *Dehorning.* All main limbs were cut back to stubs of two feet in length.

2 *Moderately heavy pruning.* The main branches and side limbs were headed back from four to six feet. This often removed three and four year old wood. This left the main limbs and side branches from six to eight feet high after the pruning. All main limbs were headed back to outward growing branches in order to avoid leaving stubs. Certain large limbs were removed entirely from the trees.

3 *Light pruning.* The ends of the main limbs were headed back lightly over the tree. These were cut back in all cases to laterals. This did not lower the height of the tree over a foot. The numerous lateral growths were not headed back. A light thinning out of the lateral growths was given.

4 *Partial or gradual dehorning.* When this method was used, one main limb was severely dehorned leaving a stub of about two feet in length as in method No. 1, another limb was pruned moderately heavy as in method No. 2. A third limb was pruned lightly as in No. 3 and the fourth and fifth limbs were left unpruned. The following year the limb, which had been pruned lightly in the preceding year, was dehorned to a stub, one of the limbs which had been unpruned, was pruned moderately, the other unpruned limb was pruned lightly and the dehorned limb and moderately pruned limb of the year before were pruned heavily and moderately respectively. This method is to be continued for three to five years until the whole tree is lowered and supplied with new, vigorous bearing wood. Advocates of this method suggest that by this means a tree can gradually be rejuvenated and rebuilt without the complete loss of a crop during any one year, as would happen in method No. 1, and might happen in method No. 2. They state that at least one-half of the tree should be bearing each year if this method is used.

5 *No pruning.* Only broken, diseased and dying limbs were removed.

Time of Pruning Each Year—Nature of Pruning in 1921, and Kind of Seasons

In 1920, the pruning was performed just as the buds were breaking. In 1921, the pruning was also done just as the buds were starting into growth.

Since the dehorned trees had made such a thick, dense growth in 1920, it was necessary in 1921 to give them a rather heavy thinning out and moderate heading back, in order to let in sunlight and establish a proper frame work of tree. A certain amount of summer pruning in both years might have checked, to some extent, the over vigorous growth and might have opened up the tree for sunlight to enter. As a result, more fruit buds might have formed. Those trees which had been pruned moderately in 1920 were again given what would be called a moderate pruning. The new growths, being numerous, were thinned out moder-

ately and the main ones were given a light to moderate heading back. The trees pruned lightly in 1920, were again pruned lightly in 1921. The check trees received no pruning as in 1920 and the partially pruned trees were treated as described under the heading, "Partial or gradual dehorning." Thus it can be seen that the same plots which were pruned heavily, moderately and lightly in 1920, were again pruned heavily, moderately and lightly, respectively in 1921. The amount of rainfall in 1920 was above normal, while the 1921 season was extremely dry during much of the growing period.

Number of Trees per Plot and Varieties Used

Eight trees were used in each method of pruning, making a total of 40 trees in the test. In each method used, four of the trees were Greensboro, an extra early variety and the other four were Elberta, a medium late variety. Since all trees in each method reacted similarly regardless of variety and since the results secured with each one of the eight trees were almost identical, it was felt that it was unnecessary to present individual tree records, which would needlessly lengthen this report *. Table I shows the average results secured per tree, in each plot of eight trees, pruned by different methods.

Results Secured in 1920

Moderate Pruning

A study of Table I. shows that as regards growth conditions, the best results were secured from those trees which had been pruned moderately. More total new wood was produced on these trees and the individual terminal growths were of desirable length and thickness. Ninety-five per cent of the buds on the new growth were fruit buds. It was estimated that these trees would have produced an average of one bushel of fruit per tree in 1921 if the freezes had not destroyed the crop. It can be seen that nothing was lost in 1920 by pruning the trees as heavy as they were pruned, since the whole orchard was in such a devitalized condition that practically no crop was borne on pruned or unpruned trees. This type of pruning reduced considerably the height and width of the trees so that they could be sprayed, pruned, thinned and the fruit picked much easier and cheaper.

Partial Pruning

Those trees which received a partial pruning gave evidence of being the next best. The limbs which had been pruned moderately made a fair terminal growth and had a good set of fruit buds. The dehorned stub, however, did not make a satisfactory growth. As a result of dehorning, one limb in addition to the moderately pruned limb, the other limbs on the tree which received either

*Individual tree records are on file at the Maryland Experiment Station, and a copy will be sent to any one who is interested.

TABLE I.

Effect of Pruning and Nitrogen on Growth and Fruitfulness per Tree of Devitalized Peach Trees.
(The result of eight trees are averaged in each case).

Growth and fruiting following pruning methods	Severity of Pruning.																	
	Heavy (Stubs)		Moderate		Light		None		Partial									
	1920	1921	1920	1921	1920	1921	1920	1921	1920					1921				
									H	Mo	Me	N	L	H	Mo	Me	N	L
Average length of terminal growth in feet	3.5	5.1	2.0	3.1	2.5	9.3	1.7	4.2	1	1.5	—	.33	.75	1.6	3.4	2.9	—	1
Average total length new wood in feet	200	1105	390	1607	90	743	60	557			160				1027			
Average total length per limb in feet	50	279	80	334	17	140	11	104			46				312			
Average height per tree in feet	7	9.7	11	12.2	13.5	13.9	14.8	14.8			13				13.1			
Average width per tree in feet	6	8.6	12	13.4	16.5	16.6	17.5	17.5			14				14.4			
Average percentage fruit buds produced	10	27	95	83	30	63	20	33	45	75	..	30	50	44	63	62	—	62
Average Yield 1920	0	......	3 peaches	.....	10 peaches		6 peaches				3 peaches							
Estimated yield 1921 in pecks		.25	....	4	....	1	..	.5							2.25			
Actual yield 1921 *		0	....	0	....	0	..	0							0			
Estimated yield in pecks for 1922		1.5	8	2.5			1.7							4.1				

*Blossoms destroyed by freezing weather.

H—Pruned stubs.
Me—Moderately pruned in 1921.
Me—Modrately pruned in 1921.
N—No pruning.
L—Lightly pruned.

a light or no pruning, made a better growth than similar limbs on trees which had not been pruned at all, or were pruned only lightly. Thus it can be seen that the lightly pruned limb on the partially pruned tree made a terminal growth of nine inches while the growth on similar limbs, where the whole tree was pruned lightly, was only 2.5 inches. Similarly the limbs receiving no pruning made three inches terminal growth, compared to 1.7 inches on similar limbs of trees which received no pruning. Thus the general health of the tree was improved by the amount of pruning it received. It happens, as we would expect from a water and food standpoint. that in the case of these devitalized peach trees, the moderately heavy pruned limb was not dwarfed in total growth in comparison to the lightly pruned limb, (Table III), as normally happens when one of two forked limbs is pruned moderately heavily on young, vigorous fruit trees. It will be noticed in this same table, however, that the dehorned limb when compared to any of the lighter pruned limbs, was dwarfed in growth. An explanation of this fact is suggested in the paragraphs following Table II.

Due to this general improvement in vigor, these trees gave promise of producing 2.25 pecks of fruit per tree in 1921. It is interesting to note that in general the percentages of fruit buds on the separate limbs were in direct proportion to the length of the terminal growth of these limbs. A more thorough discussion of this group of trees and a decision concerning the value of this pruning method, is given after Tables II and III.

Heavy Pruning or Dehorning

Since the orchard produced no crop in 1920, nothing was lost by the dehorning method. These trees, however, made such a thick, dense and vigorous growth, that practically no fruit buds were formed for the next year's crop. The total wood produced was not as much as in the case of the moderately pruned trees, but the individual growths were much longer and thicker on the stubs which remained after pruning. True, the tree was lowered considerably. This advantage, however, did not offset the greater total growth and set of fruit buds of the moderately pruned tree. This method of pruning probably will give better results than light pruning over a five year period, but it has not given better results in the two year period as measured by percentages of fruit buds and estimated yields.

Light Pruning

The light pruning did not stimulate very much terminal growth. Likewise very little total wood growth was produced. Neither did the light pruning reduce the height and width of the trees very much. The set of fruit buds was higher, however, than in the case of the dehorned trees, and it was estimated that a larger yield of fruit would have been produced if the freezes had not destroyed the crop. The future outlook for these trees was not as bright as for the dehorned trees.

No Pruning

These trees made less terminal and total growth than any of the others. The devitalized condition of these trees can be realized when it is noted that the individual terminal growths average less than two inches in length. The percentage of fruit buds, however, was a little higher than in the case of the dehorned trees. Many small limbs died throughout the tree. The main limbs were bare of fruiting wood and extended 15 feet in the air. Such trees gave little hope of producing enough profitable returns to justify their use of the ground. Similar trees, not cultivated or nitrated, would probably either have died, or become so weakened, that it would have been impossible to rejuvenate them the next year. These trees, under the good culture and spraying program and the application of nitrate of soda, however, gave some evidence of renewed vigor.

Results Secured in 1921

As stated previously, the amount of pruning given the different groups of trees in 1921 was relatively the same as that given in 1920. For example, those trees which received the heaviest pruning in 1920, were again given the heaviest pruning in 1921 in comparison to the growth which they had made. It will be noted that the trees in all groups have made a decided increase in growth and productiveness, over the previous year. Proper spraying, cultivating, worming and the addition of nitrogen, have of course, helped to bring this about. The different groups, however, have responded in about the same relative manner to the varying amounts of pruning as they did in 1920. It is interesting to note this similarity of response between the different groups, even though their general vigor is much different in the two years and though one season was dry (1921) and the other (1920) was of normal rainfall.

Pictures of trees in each plot, before and after pruning each year, have been taken. These are on file at the Maryland Experiment Station.

Moderate Pruning

The moderately pruned trees have again made the largest total growth and the most satisfactory terminal growth. With an 83 per cent set of fruit buds, these trees give promise of producing at least two bushels of fruit per tree in 1922 unless the crop is destroyed by some cause. The trees are medium in height and width and open enough so that the fruit should be well colored. At this date, these trees are by far the best in the tests. In fact, all of the trees in this group present a healthy, vigorous appearance. Apparently they ought to be able to produce at least six or eight more profitable crops of fruit. It will be recalled that all of the trees in the orchard except these 40 experimental trees were pruned by this method. Thus the orchard as a whole resembles these eight trees and is in a good healthy condition. Several profitable crops should be secured in the future.

Partial Pruning

Trees in the "partial pruned" block, with two moderately pruned limbs, two dehorned limbs and one lightly pruned limb, at this date, show a greater total production of wood than the lightly pruned trees or the checks, and nearly as much as the heavily pruned trees. The relative growth conditions of the different limbs are the same as pointed out in 1920. The actual lengths of terminal growths on all limbs are relatively greater than in 1920. This is, of course, due to the general improved health of the trees. Apparently these trees will produce about one-half as much fruit as the moderately prunes trees, but more than any of the other groups. Due to the unsatisfactory growth of the dehorned limbs and the odd appearance of such trees in an orchard, it is questionable if this system of pruning can be recommended. A fuller discussion is given after Tables II and III.

Heavy Pruning

The heavily pruned trees again made too vigorous and dense a growth to be desirable. Less total wood was produced than on the moderately pruned trees and the individual growths were so long and vegetative, that few fruit-buds were formed. It might also have paid to have done some summer pruning on these trees in 1921. Apparently these trees will produce less fruit per tree in 1922 than any of the other trees under experimentation. These trees, however, are of good size and vigor now, and if pruned moderately, should be very productive during the next few years. If the first six or eight crops are averaged, these trees will probably yield next in quantity to the moderately pruned trees.

Light Pruning

The "light pruned" trees made a fair terminal growth in 1921 and made a good increase in total wood growth over the previous year. The nitrate of soda, together with better spraying and cultural methods, no doubt, influenced this more than the light pruning. The set of fruit buds was correspondingly increased and it was estimated that these trees should produce about half a bushel of fruit per tree in 1922.

Although the lightly pruned trees should be more profitable in 1922 than the heavily pruned ones, they will probably fall far below the heavily pruned group in the future. The fact, too, that the trees so high, with bearing wood only in their tops, is a disadvantage. It is questionable if these trees would ever produce enough total new wood in any one year to pay to have them occupy the ground.

No Pruning

These trees again made the poorest growth of all and set so few fruit buds, that the estimated yield for 1922 is less than a half bushel per tree. Although they have shown a good growth response to the improved spraying, cultural and worming methods and the *application of nitrogen*, still without the added improve-

ment, which would be caused by a moderate pruning, one would not be justified in allowing them to occupy the ground, which could be used more profitably for other crops, or for young trees, if the old trees were removed.

General Nutritional Condition of the Tree in the Pruning Experiments

Kraus and Kraybill (8) in a recent paper have shown that a certain balance or ratio between the nitrates, carbohydrates and moisture, is necessary within the plant itself, if satisfactory growth and fruiting are to result. They have determined four classes or conditions as follows:

1. Though there be present an abundance of moisture and mineral nutrients, including nitrates, yet without an available carbohydrate supply vegetation is weakened and the plants are non-fruitful.
2. An abundance of moisture and mineral nutrients, especially nitrates, coupled with an available carbohydrate supply, makes for increased vegetation, barrenness and sterility.
3. A relative decrease of nitrates in proportion to the carbohydrates makes for an accumulation of the latter; and also for fruitfulness, fertility and lessened vegetation.
4. A further reduction of nitrates without inhibiting a possible increase of carbohydrates, makes for a suppression both of vegetation and fruitfulness.

These findings give us a basis for intelligently explaining most of the results secured in our pruning tests.

Apparently all of the trees in this orchard were stored with carbohydrates at the beginning of the test, but lacked a sufficient amount of water and nitrates to produce good growth and fruit. It can be said that the trees probably were in class IV as outlined by Kraus and Kraybill (8). The moderate pruning removed some of the carbohydrates and with the addition of nitrate of soda and the conservation of water through good cultural methods, these trees in this group were moved up into class III, (fair growth and good fruitfulness). The "partial pruned" trees, as a whole were brought toward this same class, although individual limbs on the tree probably varied between several of the four classes listed by these investigators. The lightly pruned trees evidently range from class IV towards class III. The trees receiving no pruning likewise range from class IV to class III, but remain closer to class IV. The heavily pruned trees with plenty of water and nitrates for the stubs left after pruning and with carbohydrates, quickly being formed when growth started in the spring, were evidently changed from class IV nearly to class II. We would expect this group to come and it gradually is coming into class III.

Growth Produced on Dehorned Limbs of Trees Pruned in Different Ways

After the season's growth in 1920, it was noticed that very little growth had been produced on the dehorned limbs of the

"partial pruned" group of trees. In some cases, this one dehorned limb had failed to grow at all. In order to secure accurate data concerning this condition, all of the growth on each stub of the eight trees was measured and the average growth per stub obtained. The result secured was compared to the average growth per stub on trees, where all limbs on the trees had been equally dehorned. In both groups of trees, the stubs left after dehorning were of the same length and comparable in every way. Table II gives the results.

TABLE II.

Growth in Feet per Dehorned Limb after Different Methods of Tree Pruning, 1921

Number of Tress used	Method of Pruning	Growth in feet per stub following dehorning in 1920, and before pruning was done in 1921	Growth in feet from stub after pruning in 1921	Growth in feet from pruned stub following heavy pruning in 1921	Growth in feet from second stub following dehorning in 1921
8	One limb dehorned	4.3 or 3.8*	3.3 or 2.9	51.3 or 45.*	48.5 or 36.*
8	All limbs dehorned	50.	20.	279.	

It can be seen that when only one limb per tree is dehorned, the resulting stub either dies or makes very little growth. If, however, all other limbs on the tree are equally dehorned, a good growth is produced from each stub. This decided difference in growth is still quite marked in the second year following pruning. The growth from a second dehorned limb in 1921, although greater than in 1920, due probably to the general increased health of the tree, was not as much as that from the heavily pruned growth on the stubs of those trees which had been completely dehorned in 1920.

Although, it is possible that the suggestion of McCallum in 1905 (10), that certain organs on a plant inhibit the growth of others, which suggestion has been emphasized more recently by the theories of Loeb (9) and Reed and Halma (11 and 12), who suggest a growth inhibiting substance and the axial gradient theory of Childs, might all be considered as possible explanations of these results, the author is inclined to interpret the results from a water relationship, such as Chandler (1) suggests, as an explanation of

* One stub died in 1920. If this is averaged with the other seven, the average growth per stub would be less, but if the dead stub is discarded, the average growth per stubs left would be more. In 1921, two of the eight stubs died.

similar results, which he secured with young three year old nursery trees. Thus he states, "The pruned tree tends to reduce the dwarfing effect of pruning by increased vigor of growth during a portion of the first season after the pruning. If we are correct in assuming that the increased water supply furnished by the undiminished (or slightly diminished) root system goes to a smaller leaf surface, then if only a shoot on the tree were pruned, the increase in vigor of new shoots from it would be less than if the leaf surface on the remainder of the tree were reduced by pruning." Commenting on his own results, which were similar to the ones presented above, he states, "It seems that the pruned branches have actually been at a disadvantage in the competition for water, which must have been the limiting factor as to growth under the conditions of this experiment. Of course, if the water supply had been abundant, it is probable that different results would have been secured; but the fact that a change in environment may so markedly change the relative response of pruned and unpruned branches , makes it clear that different branches on the same tree cannot be used in pruning experiments."

Regarding the question of an abundant water supply, it should be noted that our 1920 results, when there was more than a normal rainfall, were similar to Chandler's as well as our 1921 results, which were secured in a dry season.

A simple experiment performed by Hales (7) in 1748, strengthens this water relationship view. When he immersed the cut off end of a forked leafy twig in a jar of water and then cut off one fork of the twig, leaving a stub, and attached this stub, to a bent glass tube, the lower end of which was under mercury, the mercury was drawn up into the tube. Apparently the transpiration of the remaining leafy shoot caused any moisture present and air to be drawn away from the stub, since a negative pressure of the stub was indicated by the rise of mercury.

It appears probable then that the unpruned branches of the peach trees which blossom and leaf out quickly in the spring, might rob the dehorned stub of its full supply of moisture and thus, indirectly, its nitrate supply. The result would probably be a weaker growth than if all of the limbs had been equally dehorned. As stated previously, these were the results secured.

The Development of Individual Limbs, Pruned In Different Amounts on the Same Tree

It was interesting to note how the limbs, pruned with varying degrees of severity, reacted on the same tree. Records for each individual limb were kept separately in the case of the "partial pruned" trees. Table III. shows the results secured.

TABLE III.

Development of Limbs Pruned Differently on Same Tree

Growth and fruiting following pruning methods.	Heavy (stubs) 1920	1921	Moderate 1920	1921	Light 1920	1921	None 1920	1921
Average length terminal growth in feet.	1.	1.5	1.5	3.4	.75	——	.33	——
	——	1.6*	——	2.9	——	1.	——	——
Total length of new wood in feet.	3.8	45.	100.	440.	42.	——	13.	——
	——	48.*	——	310.	——	180.	——	——
Height in feet.	4.	5.	10.5	12.	13.5	——	14.8	——
		4.5*	——	10.	——	13.5	——	——
Width in feet.	2.	3.	5.	6.	6.8	——	6.8	——
		2.5*	——	5.	——	6.5	——	——
Percentage fruit buds.	45.	50.	95.	85.	40.	——	25.	——
	——	44.*	——	90.	——	65.	——	——
Yield in 1920.	0.	——	0.	——	2 peaches	——	1 peach	——
Estimated yield in pecks for 1921.	——	1 peach	——	1.	——	.25	.25	——
	——	0.*	——	.5	——	——	——	——
(a) Actual yield for 1921	——	0.	——	0.	——	——	0.	——
	——	0.*	——	0.	——	0.	——	——
Estimated yield in pecks for 1922.	.25		——	2.	——	——	——	——
	3	peaches*	——	1.25	——	.50	——	——

TABLE III EXPLAINED

It will be recalled that on the partially pruned trees in 1920, one limb was dehorned, leaving a stub of two feet in length; one limb was pruned moderately; one limb was pruned lightly and the other two limbs were unpruned.

In 1921, the growth on the dehorned limb was thinned out and headed back, fairly heavy. The growth on the moderately pruned limb was thinned out moderately and the main laterals headed back lightly. The limb pruned lightly in 1920 was dehorned in 1921. One of the limbs, which had not been pruned in 1920 was pruned lightly in 1921, and the other check, or no pruning limb, was pruned moderately in this year.

The table is so arranged that the 1921 growth of each limb pruned in the same relative amounts each year, is directly opposite the growth recorded for 1920. These records are above the dotted line. Thus, under the moderately pruned heading, when total wood growth is considered, it can be seen that 100 feet was produced on this limb in 1920 and 440 feet in 1921. Records of the other results are arranged in the same manner. The figures below the dotted line in each column represent the growth conditions resulting in 1921 on limbs pruned in a different manner than they had been pruned in 1920. Thus under "heavy pruning" when total wood growth is considered, it can be seen that

* Record for stub removed in 1921.
(a) Crop lost by freezes at blooming time.

the growth from the second stub was 48 feet. As stated above this was the limb which had been pruned lightly in 1920, and the records show that it had made 42 feet in growth in that year. The growth records in 1921 as shown below the dotted line, under the moderate and light pruning columns, can likewise be understood. In 1921, all limbs were pruned to some extent so growth records do not appear under the "no pruning" column.

Results Secured

It can be seen that the growth and fruit responses of the different limbs, except when dehorning was practiced, was in direct proportion to the amount of pruning which each limb received. Thus the moderately pruned limbs produced terminal growths of 18 inches in 1920, the growths on the lightly pruned limbs were nine inches in length and those on the limbs receiving no pruning were from three to four inches long. Total wood growth, percentage of fruit buds and estimated yields, varied in the same relative order. Growth on the stubs, however, was not satisfactory. The stubs either died or made a few weak and slender growths of about a foot in length. It is true that practically no buds were left on the limbs after dehorning and it was usually necessary for adventitious or dormant buds to be forced out before growth in length and leaf area could be produced on these stubs. However, even if this did give the other buds a slight advantage in getting started, it is hardly possible that this could have accounted for the big difference in growth between that on the stubs and the limbs pruned moderately. It will be remembered that the growth was much greater per stub when all limbs were dehorned (Table II), yet in this latter case, all stubs of the tree had to force out adventitious or dormant buds also. It might be said that the exposed end of the stub would lose water through evaporation and thus make nearly as much demand for water as the growth on the moderately pruned tree, thus questioning the water relationship view. Still good growth did not result from this stub on the partially pruned trees and it did result from the completely dehorned tree when all limbs had exposed surfaces. Gunderson (6) in some dehorning experiments with young peach trees following winter injury, found that waxing of the stubs on completely dehorned trees, did not prevent their dying as compared to unwaxed stubs on other dehorned trees. He states, "It may be concluded, therefore, that evaporation at the cut surfaces of the dehorned trees was not directly responsible for their death. The dehorning of these trees resulted in an extreme reduction in the amount of leaf surface with a corresponding reduction in amount of transpiration. As it is quite probable that transpiration in peach trees exerts some effect upon the flow of sap, it seems likely that the trees of Row 2 (dehorned) did not draw a sufficient amount of sap from their roots to sustain them and permit growth. Then too, the season was extremely hot and dry."

If much evaporation did take place from the exposed stub, it is possible that the mineral nutrients might either become so concentrated, or gums might be formed from the injury so that the

water conducting vessels would become clogged, or partly so. In such a case, any buds along the stub or adventitious buds might have their supply of water directly reduced, compared to buds on other limbs of the tree, or the sap supply might be so concentrated that the buds could not obtain and use it so freely. Their future growth might thus be checked at least on the ends of the stub. Of course, stubs on completely dehorned trees should all be affected in the same way and yet good growth resulted on each stub of the dehorned trees. In addition, growth on the one dehorned limb of the partially pruned tree was as good or better at the end as anywhere else on the stub. Thus the explanation given following Table II appears to be the most plausible.

Note that the total growth from the limbs dehorned in 1921, was much smaller than that from other limbs on the same tree which were not dehorned.

It is interesting to note that although the growth produced on all limbs was much greater in 1921 than in 1920, indicating the much improved health of the trees, still the relative amounts on the different limbs was the same as in 1920.

It thus appears that the effects of pruning are rather localized. Although the general health of all limbs on the tree is improved by the better orchard methods, still limbs of the same tree react as individuals and show a stimulation in direct comparison to the amount of pruning that they receive.

Apparently limbs on the same tree react to different amounts of pruning in the same way as do whole trees, where they are pruned by each of the different methods. Thus the moderately pruned trees have made better growth than the lightly pruned ones with the checks being poorest. This same order and rank is shown to occur with the different limbs on the same tree.

General Summary

It has been shown that ten year old devitalized peach trees can be profitably rejuvenated by proper methods of soil management, spraying, worming, fertilizing and pruning. Although good methods of soil management, worming and spraying and applications of nitrate of soda, have improved the general health of these trees, still best results were not secured unless a certain amount of pruning was given. In this test, the best results were secured when a moderately heavy pruning (cuting back into three or four year old wood), was given. Similar results have been found by Close (3) and by Eustace (4), Whitten (14), Gunderson (6), and others, working with winter injured trees. By a moderately heavy pruning, the height of the trees has been noticeably lowered and in two years time, a new top has been formed, and so much vigorous growth has been stimulated through the lower parts of the tree, that such trees should produce maximum crops for six or eight years, if properly managed.

Although the partially pruned trees were stimulated as a whole, so that certain of the limbs will probably bear a fair crop of fruit, still the growth on the dehorned limbs was so unsatisfactory that the purpose sought, (the gradual rebuilding of the tree), was not

attained. In addition, these trees present such an unbalanced and irregular growth that an orchard pruned by this method would have a very poor appearance. Provided each tree had enough main limbs to start with, so that a stub or two could be sacrificed if necessary without seriously hurting the shape of the tree, this method would, no doubt, be better than the lightly pruned trees and might possibly equal the heavily pruned trees in yield over a six or eight year average. The method would be very questionable if only three or four limbs were available on each tree in the beginning.

Those trees which were dehorned made a very dense, vigorous growth during both years. Not only was the size of tree considerably dwarfed, but few fruit buds were formed on the long, over-vegetative shoots. (Summer pruning of these trees during both years, might have been beneficial, if growth would not have been checked too much). This method was not as good as when a moderate pruning was given. With moderate or light pruning in the future, these trees will, no doubt, produce several profitable crops. Although practically no crop was produced the first two years, the average production over a six or eight year period will probably exceed that from the trees in all other methods, except those pruned moderately. If many of these dehorned trees had died as they often do when in an extremely low state of vigor, this method would have been poorer than all others. This possibility must be considered when dehorning weak trees.

Although light pruning produced a certain amount of stimulation in growth and fruit during the two years, still it is very questionable whether the average production from these trees will be enough in the next six or eight years to warrant their use of the ground. Any fruit borne would be 15 feet from the ground and the expense of picking, spraying and pruning, would be very high with these trees.

The block of trees, which received no pruning, demonstrated that peach orchards cannot be profitably rejuvenated without pruning.

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A Note on the Fruiting Habit of the Concord Grape

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THE results reported below were obtained in a pruning experiment conducted by the Michigan Agricultural College in the vineyard of J. P. Munson near Grand Rapids. Data were secured that showed the weight of the grapes produced by the shoot or shoots growing from each node of the fruiting canes of forty-eight vines. It was noted that the buds at a node of a fruiting cane might either fail to grow at all or produce one shoot or two shoots, the latter being a rather infrequent condition. Some of these shoots were found to be productive and others produced no grapes. In cases where two shoots were produced from a single node, both shoots might be productive or barren or there might be one shoot of each type.

In considering these results, it should be noted that the Munson vineyard had produced a heavy crop in 1920, but there seemed to be no difficulty in securing well-matured canes for the 1921 crop. Southern Michigan suffered from an early spring freeze which killed a large percentage of the buds and shoots of those vineyards which started early. The Munson vineyard, being located a little farther north and on heavier soil, did not seem to be injured to any considerable extent by this freeze. However, a greater or lesser number of these buds may have been killed or injured by this freeze and passed unnoticed. It is not believed that

the number of buds so injured was large. The yield of grapes from all productive shoots was greatly reduced by a hailstorm in July. It was estimated that about 50 per cent. of the berries were cut by hail.

The question of the proper number of nodes to be left in pruning a fruiting cane of a grape vine is of considerable practical importance to the grower. This evidently depends upon the relative fruitfulness of the different nodes on the cane. Keffer[1] published data on this subject which show the average production per node increased from the first (toward the base of the cane) node of the cane with an average yield of 2.3 ounces, until the average yield of the fourth node was 6.3 ounces, of the fifth 5.9 ounces, and of the sixth 6.4 ounces. The average yield per node then decreased with an increase in the distance from the base of the cane until an average yield of 4.3 ounces was obtained for the twelfth node, which was the last node studied. Maney[2] also found this same decrease in yield at the base of the fruiting cane, as was indicated by the lower comparative yield of the spur system of pruning.

The results of an examination of the data secured in the Munson vineyard as to the relative productivity of the different nodes of the fruiting canes follow:

Average Yield of the Different Fruiting Nodes of the Fruiting Canes.

Number of Node from base of cane	Number of Nodes Fruiting	Average Yield ounces
1	320	3.16
2	322	4.00
3	250	5.11
4	254	5.81
5	214	5.61
6	156	6.06
7	97	5.82
8	64	5.76
9	32	4.99
10	13	4.77

The results conform closely to those of Keffer, and, although the curve is not as regular as might be wished, there is an evident optimum production at the sixth node, with comparatively high average yields for the fourth, fifth, seventh, and eigth nodes. However, the above table does not consider the effect of the sterile shoots and the buds that failed to grow. Consideration of these factors considerably alters the appearance of the data as shown in the following table:

[1]Keffer, C. A. The Fruiting Habit of the Grape, Tennessee Station Bul. 77, (1906), 35-46.

[2]Maney, T. J. Grape Pruning: The Spur and Long Cane Systems Compared, Iowa Station Bul. 160 (1915), 211-232.

Average Yield of the Different Nodes of the Fruiting Canes

Number of Node from base of cane.	Total Number of Nodes	Average Yield ounces
1	690	1.46
2	534	2.41
3	390	3.28
4	376	3.95
5	336	3.62
6	257	3.73
7	187	3.09
8	118	3.15
9	69	2.35
10	46	1.41

It is noticable that the point of optimum yield is shifted toward the base of the cane; the highest yield being found at the fourth node. Beyond the sixth node the average yield falls off with great rapidity, falling below the low yield at the base of the cane by the time the tenth node is reached. It is possible that this tremendous decline is a seasonal condition; but it is very probable that the lessened productivity of the outer buds exists to a greater or lesser degree each season.

The question is a practical one; how many nodes are we to leave on our fruiting canes? The following table is offered as a step toward the solution of the problem:

Average Yield of all the Buds on Fruiting Canes of Different Lengths

Number of buds on cane	Number of canes of given number of nodes.	Average Yield per node per cane, ounces.
1	156	2.6
2	144	1.9
3	14	1.5
4	40	2.3
5	79	2.7
6	70	2.3
7	69	3.1
8	49	2.8
9	23	3.8
10	21	2.9
11	14	2.2
12	7	3.2
13	1	5.9
14	3	3.7

The curve produced by plotting the above data is very irregular owing, doubtless, to the limited number of canes studied. How-

ever, it may be smoothed out to a considerable extent by grouping adjacent classes as follows, one and two bud spurs being considered separately as above:

Number of buds on cane	Number of canes of given number of nodes.	Average Yield per node per cane, ounces.
3, 4, 5	133	2.5
6, 7	139	2.7
8, 9	72	3.1
10 to 14	46	2.9

The results obtained do not justify a decision as to what the ideal length of cane may be. It seems, however, that the buds of an average spur are not as productive as those of a cane of eight to nine buds length, and should be used only when necessary to secure proper renewal. On the other hand, it appears that a cane may be left too long to produce the highest average yield per node. Observations are necessary over a series of years to determine whether there are any seasonal differences in this regard. It will be necessary to determine, further, the effect of vigor and maturity of cane on the most productive cane length. Work is outlined along these lines for 1922.

Preliminary Report on the Use of Sodium Silicate (Water Glass) as a Wound Dressing

By W. J. Young, *Experiment Station, Worcester, Ohio.*

THERE is a popular opinion in the southern states that the Muscadine grape should not be pruned. This view no doubt had its origin in the injurious results which may follow late winter pruning. If pruning is delayed much after January first, bleeding is apt to be excessive, and under certain conditions the vines may literally bleed to death. This circumstance led to some preliminary tests of wound dressings at the South Carolina Experiment Station two years ago.

A dressing was required which would unite with water and thus penetrate the freshly cut surface of the wood, but which at the same time would form an impervious substance on exposure to the air and thus effectually seal the cut ends of the sap vessels.

The solution of sodium silicate, the water glass commonly used for preserving eggs, seemed to offer possibilities in this direction and was included in the test. It was applied by painting or swabbing upon the freshly made pruning wounds and was used full strength and hot. The treatment more than fulfilled all expectations. Paints, Coal-tar, grafting-wax and all other treatments except the water-glass were useless and the usual amount

of bleeding followed their application. Cuts to which the water-glass was applied, however, remained perfectly dry and bled not at all.

It was intended to repeat the experiment and especially to determine whether the water-glass would be as effective if used cold and also whether a more dilute solution could be employed. It is desirable to determine, furthermore, the effect of the water-glass upon the treated plant, but no injurious results are anticipated as the agent is so nearly inert. It is important also to discover if wounds so treated offer any resistance to the entrance of wood destroying fungi. As the opportunity to complete the test has not been offered, it seemed desirable to present a preliminary report at this time in order that horticultrists might have the benefit of the method.

Histological Studies of Apple Tree Crotches

By L. H. MacDaniels, *Cornell University, Ithaca, N. Y.*

THE data upon which this address was based will be published in a future bulletin of the Cornell Experiment Station.

Root Development of the Apple as Affected by Cultural Practices

By F. P. Cullinan, *Purdue University, Lafayette, Ind.*

IN the spring of 1914, fifty apple trees of the variety Grimes were planted on the plots in an orchard soil management experiment being conducted by the Purdue University Agricultural Experiment Station. This experiment includes five plots each under a given set of soil treatments thus making ten trees to each plot. The trees were planted in the center of the square between the permanent tree rows and received the same soil treatment as the permanent trees in the plot. These interplants were to be removed from the soil for the purpose of studying the effects the soil treatment had on the growth and development of the root systems. This paper will cover observations on three of the plots which have had a continuous soil treatment from the time the interplants were set until they were removed from the soil—namely, tillage, straw mulch and sod. The trees were in their eighth seasons growth when dug in the summer of 1921.

Briefly, the treatment which these trees have received is as follows: The soil in the tilled plots was broken in the spring with a breaking plow when the cover crop was turned under. During the last three years the cover crop has been disked under. An average of five cultivations has been given each year during the

growing season. The cover crop has been seeded about the first of August. Rye, vetch, millet and a combination of rye and vetch have been used as cover crops. The trees in the straw mulch plot were planted in sod and have each received annually a heavy application of wheat straw, consisting of one bale weighing about eighty pounds.

This material was spread as evenly as possible under the tree and out under the tips of the outside branches. Each year the mulch collar was extended to keep pace with the growth and spread of the top. The yearly accumulation of the decaying straw formed a heavy mulch. The trees in the sod plot were also planted in sod consisting largely of timothy and blue grass, and have remained under a treatment of sod culture. The grass on the plot was cut and allowed to fall back on the ground. In most seasons the growth of grass was very light and there was practically no accumulation of a grass mulch under the trees. No commercial fertilizers were added to any of these trees.

The soil on all plots in which these trees were planted may be said to be a clay silt containing about 70 per cent silt and 16 per cent clay. It is a glacial drift soil in which there is little difference in the makeup of the subsoil and surface soil as revealed by the mechanical analyses. The surface soil is low in humus and contains little more organic matter than the subsoil. It would be considered a very poor soil for most farm crops without the application of commercial fertilizers.

To remove eight year old apple trees from the soil for the purpose of studying the root system and particularly the relative position of the roots in the soil, is a rather difficult task. Some investigators have washed out a few trees to study the root behavior, but this was not deemed practicable with a large number of trees. In this study the soil was removed from around the root system and the character of the root system, spread of roots, depth and size of roots, were noted. The trees were then removed from the soil and the weights of the tree, top and root, were made. By weighing the trees it was possible to obtain a quantitative measurement of the relationship between the top and root system. In removing the trees from the soil, dynamite was the agency employed for loosening the soil. Four or five charges, depending upon the size of the tree, were arranged in a circle about two feet from the trunk. Another set of five to seven charges was placed in an outer circle about four feet from the trunk, spacing these charges alternately between those in the first circle. One-half stick of 40 per cent dynamite was used in each hole and placed at a depth of 2½ to 3 feet in the soil. The entire charge was exploded with a battery. Usually the force of the explosion was sufficient to jar the surface soil and break up the sub-soil.

The loose soil was then removed. When the main root system was uncovered, the individual roots were carefully followed to their extremities and loosened from the soil. The entire root systems with the exception of the small fibrous roots that could not be collected were removed. In some cases nearly all of the

root system was removed intact, but with some of the larger trees the secondary roots were often broken and had to be removed separately. Roots that were in the path of the full force of the explosion were sometimes severed from the main roots. However, after the tree was removed from the soil all broken roots were searched out for weighing. It is doubtful if any roots left in the soil averaged over an eighth of an inch in diameter, and these were usually at the extremity of the main roots where they divided into many brittle branches that were easily broken if the soil in which they had penetrated, was not sufficiently loosened. When the tree was removed, all soil that adhered to the roots was jarred loose or, if necessary, washed off with water.

Trees were weighed on a platform scales with a large wooden frame supported on the platform. It was necessary, owing to the size of the trees, to cut off the root system and weigh the roots and tops separately. In severing the root system from the trunk, the cut was always made just above the uppermost root. Only that portion of the tree which served as a true root system was considered such. Some such method of procedure is almost necessary to avoid the error which might occur in weighing when a portion of the trunk that was below the soil line was weighed with the root system. Eight trees were removed from each plot. In Table I the average weights of the trees dug from the three plots, culivation, straw mulch, and sod are given:

TABLE I.

Average Weight of Trees in Pounds—Top and Roots

Number trees	Soil treatment	Weight of trees	Weight of top	Weight of roots	Per cent weight of tops	Per cent weight of roots
	Tillage					
8	cover crop	303.6	230.4	73.21	76.3	23.7
8	Straw mulch	250.7	186.4	64.42	73.9	26.1
8	Sod	14.2	10.0	4.2	68.4	31.6

It will be noted that the trees under cultivation averaged larger in weight than the trees in straw mulch. The weights of the trees in sod show that the trees under this method of treatment were deprived of the necessary nutrients which were evidently furnished under cultivation and straw mulch. As a consequence the growth of top and roots of these trees was seriously dwarfed. The trees in sod averaged slightly more than a centimeter in annual girth gain during the time they were in the orchard. Just why the trees in cultivation are about fifty pounds per tree heavier than those in straw mulch is not quite apparent. Circumference measurements show little difference in the annual girth increase of trees from these two plots. There is a greater difference proportionately between the top weights of trees in these two plots than there is between root weights. The cultivated trees are making more vegetative growth as indicated by the

quantitative measurements; yet, they have not produced the fruit in the first three years that the trees in straw mulch have. It is quite possible that the mulch conditions were in the last few years, (as the roots of the tree extended beyond the mulch collar), more favorable to a checking of vegetative growth and thus favor fruitfulness. The growth of trees in straw mulch then, as measured by total weight, may have been reduced when these trees came into bearing. The following table gives the growth and yield data of these trees—eight to a plot.

TABLE II.

Treatment	Average girth gain per tree 1915—1920	Total Yield of fruit in pounds 1919	1920	Average number of fruits per tree in 1921
Cultivation	5.44 cm.	9.25	63.00	181
Straw mulch	5.08 cm.	64.57	190.25	207
Sod	1.15 cm.	0.	0.	0

In a study of the figures on the relationship between weights of top and roots presented in Table I, it will be noted that the slower growing trees, particularly the trees in sod, have a greater percentage of their total weight in root system than the trees in cultivation or straw mulch. In this connection the objection might be offered that with the small trees growing in sod, a greater percentage of the root system was recovered from the soil in digging, than was removed from the soil under tillage or straw mulch. The differences could not be accounted for in this way. In support of this conclusion, it may be pointed out that in an investigation of certain four year old interplant trees in these same plots, it was shown by Oskamp* in 1916, that trees growing under a system of sod alone had conisderably larger root systems in proportion to their tops than trees growing under cultivation.

The root systems of the trees in cultivation were quite symmetrical in spread, the main roots, as well as the laterals, ramified into all parts of the soil surrounding the trees. The main roots of the trees in cultivation were found at a greater depth in the soil than those from the trees in any of the other plots. It was apparent that the soil in which the tilled trees were growing was in a better physical condition at a greater depth than under the straw mulch or sod plot. However, analyses of the soil made when the trees were removed showed no greater per cent of total nitrogen or organic matter in the sub-soil of the trees under tillage, than under straw mulch or sod. In the surface soil of the cultivated plots, the total nitrogen content of the soil at this time was also lower than on other plots. This is not sur-

* Oskamp, J., Root Studies. Ind. Agr. Expt. Sta. 1916 (Unpublished).

prising when we consider that the soil has been too poor to support a good growth of cover crop without fertilization. The soil analyses made during the last three years show that cultivation has been burning out the humus which it has not been possible to return through cover crops. Yet, up to the time the trees were dug it does not appear that the vegetative welfare of the trees has been impaired by this decrease in organic matter.

In contrast to the depth of roots under cultivation, is the very shallow root system of the trees under straw mulch, which came very close to the surface of the soil. In fact, roots of one-half inch and over in size were found growing on the surface of the soil underneath the straw mulch. Very many fibrous roots were to be found on the surface of the soil feeding in the decayed material. Approximately, 90 per cent of the root systems of the trees in straw mulch came within the first two feet of soil, 75 to 80 per cent of the root systems of these trees was in the first twelve inches with a network of the fibrous roots just underneath the surface of the soil, or penetrating the straw mulch itself.

The trees in sod had not made much growth. The root system as a whole did not exhibit a tendency to come as near the surface of the soil as the roots under straw mulch. This is probably due to the fact, as has been previously pointed out, that the grass produced on this plot was not of sufficient quantity to form a decayed mulch. The small amount of growth made by the roots under sod has apparently been a continuation in growth of the main roots that the tree possessed when it was planted. The trees were planted directly in sod where soil conditions were not so favorable for the early establishment of the roots.

There was not a noticeable difference in the character of some of the root systems on the different plots. Under tillage the roots were large but numerously branched, spreading uniformly under the trees. Under straw mulch there were usually many more in number than under cultivation, yet the individual roots averaged much smaller in diameter. Many of the long slender roots and fibrous ones that were found under straw mulch were confined to the area covered with the mulch. It should be remembered that under tillage the entire area received this treatment while on the straw mulch plot the mulch was confined to the area under the spread of the branches, or slightly outside.

The growth and behavior of the roots of the trees under the systems of culture described have undoubtedly been influenced by these treatments. The size, position and branching habit of the roots have been influenced, if not clearly modified in their behavior, by the external conditions under which they have grown. Yet it becomes a difficult problem to segregate the causes of such behavior. Our knowledge of the root behavior of trees is indeed very meager, and it would be assuming too much to try and assign the causes for the growth conditions observed, especially morphological differences, without a more careful inquiry into the activities of these underground parts throughout the year. Reasons for branching, distribution in the soil, and the growth

of those roots most intimately concerned with the vital processes of tree growth, cannot be deducted alone from quantitative measurements. Such factors as moisture, temperature, aeration, and the activity of soil organisms must be taken into consideration.

Under cultivation there has unquestionably been given greater aeration to the sub-soil by the tillage practices that have been followed. Furthermore, these tillage practices may be responsible for the fact that the roots under cultivation are not as near the surface of the soil. Many of the young, growing roots have been pruned off in the regular cultivations. An examination of the roots underneath the tree near the trunk where the tillage tools have not disturbed the soil in recent years, showed many young roots near the surface of the soil, or penetrating into a clump of grass roots. This suggests that many young roots are pruned off by tillage. Furthermore, the temperature of the soil under tillage responds quickly to the variations in air temperatures. During the winter months alternate freezing and thawing of the soil has occurred on the plot under tillage. This too, may account for the absence of roots near the surface.

Under straw mulch the external conditions have been such as to encourage the formation of roots near the surface of the soil. The soil underneath the mulch has been kept very moist at the surface throughout the entire year. The presence of an abundance of organic matter and moisture has been favorable for nitrification on the surface of the soil, and food material for the roots has thus been made available. There has been no stirring of this soil to remove any of the roots, and they have grown unhindered near the surface, or into the straw mulch. This apparently has not proven harmful to the tree so long as the mulch has been applied each year to maintain these conditions. We can easily speculate what might happen if the mulch material were not reinforced, or was permitted to dry out. In dry seasons such as the past growing season was, there is a tendency for the moisture to evaporate near the edge of the mulch collar. Then again, the question of soil temperature underneath the mulch is a factor that may account for some of the variations in tree and root growth between trees under mulch and under tillage. Oskamp (Jour. of Agr. Research Vol. V., No. 4:173-177) has reported that the soil at root depth cools off more slowly under straw mulch in the fall and warms up more slowly in the spring than under tillage. "The extreme diurnal and annual fluctuations in soil temperature noted under tillage are more equalized under straw mulch."

One of the noticeable characteristics of the root growth of the trees in these experiments, has been the relatively shallow roots of the trees. This was quite unexpected. The character of the soil undoubtedly has much to do with the depth of rooting. Ballantyne (Utah Agr. Expt. Sta. Bul. 143 p. 13) has reported that in very thin soils in Utah, roots seek the water table at a depth of ten feet and have been found in large numbers at a depth of four to six feet below the surface. This was a clay soil which was very low in moisture in the first three feet and which

was underlain with a loose, moist, sandy sub-soil. Goff (Wis. Agr. Expt. Sta. Rpt. 1897: 295-298) reported apple tree roots going to a depth of nine feet in a soil which was sandy clay at the surface becoming nearly pure sand at a depth of five feet. Three year old trees at Lafayette, growing in a clay loam soil with a sandy and gravelly subsoil, were found sending some of their roots to a greater depth than eight year old trees at Laurel, Indiana. The subsoil at Laurel is a very heavy, silty clay with a high water holding capacity. The growth behavior of roots in such a soil through which water percolates slowly may be different from a lighter soil through which water percolates more freely. Analyses of the subsoil show a high acidity. There seemed to be little tendency for the main roots in general, to grow much below the depth at which they were planted in the orchard. The growth was very largely a horizontal extension of the original roots on the tree, and the new roots that were formed followed the same course. The vertical depth was greater in the cultivation plots than in the other plots.

In regions where the straw mulch system of soil managemnt is practiced, this information on the behavior of roots under such a treatment, is of practical importance. To break up an orchard that has long been under the straw mulch system does not appear to be a wise practice, unless possibly the trees are so strong vegetatively as to withstand such a severe root pruning as would necessarily be given. Furthermore, the practice of applying a heavy mulch of straw or manure for several years, and then abandoning this practice might also in some locations, prove to be a detriment to tree growth when this was discontinued.

Length of Life of Apple Trees Based on Observations in Virginia and Michigan

By Roy E. Marshall, *Michigan Agricultural College, East Lansing, Michigan.*

Most horticulturists will undoubtedly admit that, generally speaking, fruit trees, especially apples, live longer in the section of the country occupied by Michigan, New York and the New England states than in the southern and possibly western fruit regions. When we attempt to determine why trees live longer in some sections than in others, such questions as the following arise: Do the southern orchards die of old age sooner than the northern ones? Are certain diseases, more prevalent in the South, responsible for shortening the lives of orchards in that section? Are the varieties adapted to the southern states shorter lived ones than those generally grown in the North? Is early bearing usually associated with early death in trees and late bearing associated

with long life? And if so, may not the fact that trees come into bearing earlier in the South be responsible for an early death.

This question was first brought to my attention by Chandler more than a year ago after he had noted in Virginia Extension Bulletin No. 40 that the writer had found that approximately 1.4 per cent of some 2,000,000 commercial apple trees of Virginia were over 30 years old, and further, that only .2 per cent were over 40 years of age. Similar statistics are not available for commercial plantings of northern states, but it is a well known fact that the percentage of old trees is much higher than in the southern states; in fact trees 30 to 40 years of age are thought to be in their prime or middle life and orchards 35 and more years old frequently change hands at prices considered good for orchards of any age in Michigan and New York, while such statements would apply to trees some ten years younger in Virginia.

Further reference to the Virginia data shows that fully 60 per cent of the apple trees considered in the survey were between the ages of one and twelve years. This, together with observation, indicates that Virginia has made plantings on such an extensive scale during recent years that the number of old trees appears rather insignificant in comparison to the younger ones.

Yellow Newtown, (Albemarle Pippin) is generally regarded as a variety long grown in Virginia, but in rather limited localities. The 1917 census, heretofore mentioned, shows approximately 10 per cent of the trees of this variety to be older than 30 years and only 2.1 per cent older than 40 years. Fully half of the trees of this variety were between the ages of 20 and 30 years. Without information as to the extent that Yellow Newtown was planted 30 to 50 years ago, we might see an indication in these data that this variety dies of old age rather young.

Winesap, I believe, is regarded as a comparatively longlived variety in the South. Only 1.4 per cent of the trees of this variety were over 30 and .3 per cent more than 40 years old. On the other hand, over 80 per cent of approximately 420,000 Winesap trees were less than 20 years old, showing clearly that planting of this variety during recent years have been so extensive as to overshadow the numbers of old trees. We find this suggestion more forcefully emphasized in noting that more than 85 per cent of some 630,000 York Imperial trees were less than 20 years of age, while slightly more than 1 per cent were over 30 and a negligible number more than 40 years old. Thus it appears that nothing can be found in the statistics gathered in preparation for the above mentioned report that will bear out the contention that trees die younger in the South. It merely emphasizes the fact that Virginia is to be regarded as a comparatively new state in extensive orcharding.

However, the orchards above 40 years old in Virginia are considered exceptional while they are not uncommon in the northern states. It is quite unlikely that plantings were on a similar scale in these two sections, but it seems reasonable to believe that plantings were made on a sufficient scale in Virginia at such times to have resulted in greater numbers of old trees today, had the trees lived.

In the matter of diseases and insects, we know that Illinois blister canker has been responsible for the premature death of numerous trees, especially of the Ben Davis variety in southern and middle western states and that few Grimes Golden trees of the Shenandoah-Cumberland Valley pass the twentieth year because of the prevalence of collar rot, while Grimes Golden trees 40 and more years old are not uncommon in Michigan. Again, zylaria root rot has resulted in the early death of many trees in the Virginias and to the west of these states, while armillaria root rot has been responsible for a heavier toll in the Pacific Northwest. These diseases, while occasionally found in the northern states, result in the losses of very few trees, or at least the trees seem to resist the attacks for a longer time in the northern states. On the other hand, San Jose scale has undoubtedly resulted in heavier losses of trees in Michigan than in Virginia and the Baldwin and Hubbardston have sustained heavy losses due to winter injury. All things considered, it seems to me that diseases which threaten the lives of trees (not quality of fruit) are more prevalent in the South than in the North.

In attempting to answer the question "Are varieties adapted to the southern states shorter-lived than those commonly grown in the northern states?," we are confronted with another question: "Which of our common varieties are long-lived?" Beach, in "Apples of New York," mentions the following varieties, among others, as being long-lived: Baldwin, Northern Spy, Ontario, Perry Russett, Pewaukee, Rhoad Island Greening, Tolman, Twenty Ounce Westfield, Yellow Bellflower, Chenago, Fall Orange, Fall Pippin, Fameuse, Holland Pippin, Maiden Blush, Ribston, Shiawassee and Sweet Bough. With the exceptions of Yellow Bellflower, Fall Pippin, Maiden Blush and Sweet Bough, I believe these are varieties grown to a very limited extent outside of New England, New York and Michigan; at least they are not generally regarded as standard commercial varieties in other sections. Fall Pippin and Maiden Blush are regarded as commercial sorts in several sections, while yellow Bellflower is grown commercially in California.

Beach mentions Missouri Pippin, Thompkins King, Wagener and Winesap as being short lived. The comparatively short life of Tompkins King is associated with collor rot. Winesap is referred to as being short lived in unfavorable situations in New York. Beach states, in regard to Wagener, "The tree is often short-lived, but some report it as longer lived when top-worked upon hardier and more vigorous stock, such as Northern Spy, Baldwin and Tolman Sweet," indicating root troubles or that the trunk is susceptible to collor-rot. As I recall Missouri Pippin in the Missouri Valley, it is susceptible to practically all of the common tree troubles. Missouri Pippin is essentially a middle-western variety, Winesap a variety adapted to southern latitudes and the Pacific Northwest, and Tompkins King and Wagener are grown commercially in the northeastern quarter of the country and in the Pacific Northwest. Thus it seems that these four varieties are short-lived because of susceptibility to root and trunk troubles or because of planting under unfavorable environment and further that the only southern variety mentioned as being short lived in New York is generally regarded as being

long-lived in the regions to which it is adapted. Furthermore, fully as many of the varieties mentioned by Beach as being moderately long-lived or moderately short-lived are varieties of northern adaptation as of southern adaptation.

It has frequently occurred to the writer that since early bearing varieties, such as King David, Jonathan, Grimes Golden, Yellow Transparent and others, were usually considered rather short-lived, and since many old orchards indicate that late bearing varieties such as Yellow Newtown, Northern Spy and Baldwin are long-lived, that, generally speaking, early bearing varieties die young and late bearing varieties are long-lived. However, the following compilation of the more commonly known varieties from Beach's Apples of New York clearly shows that early bearing varieties are not necessarily short lived although we might infer that late bearing varieties are usually long-lived, were it not for the fact that a late-bearing variety must be long lived or have some other very outstanding characteristics to be worthy of a place in the lists of standard varieties.

EARLY BEARING VARIETIES

Long-lived	*Moderately Long-lived*	*Short-lived*
Bethel	Ben Davis	Missouri Pippin
Chenango	Early Harvest	Wagener
Keswick	Golden Sweet	Winesap
Maiden Blush	Jersey Sweet	
Tolman	Sweet Winesap	
Twenty Ounce	Red Astrachan	
Sweet Bough		

LATE BEARING VARIETIES

Long-lived	*Moderately Long lived*	*Short-lived*
Baldwin	(None)	Tompkins King
Northern Spy		
R. I. Greening		
Rock Pippin		
Shiawassee		

In summing up, it seems to me that apple trees die more frequently because of diseases of the "collar" or roots, lack of hardiness, planting in unfavorable environments, and neglect, rather than from old age and that the varieties which are most resistant live the longest and, further, that diseases threatening the lives of apple trees are more prevalent in southern states than in the northeast quarter of the United States.

Observations on the Factors Influencing the Length of Life of Apple Trees in W. Virginia

By H. L. Crane, *West Virginia University, Morgantown, W. Va.*

ORCHARD surveys made in several of the more important apple growing counties of New York State show that the largest returns are secured from orchards between the ages of 40 and 55 years and that many orchards considerably older than these bear profitable crops. On the other hand a recent survey of Virgina shows that only one per cent of the apple trees of that state are over 30 years old. In West Virginia, surveys have been made of two of the important fruit counties, Berkeley and Jefferson. These show that approximately only one per cent of the trees are over 30 years old. The fruit industry in this section is young as compared to New York but this fact would not account for the small per cent of old trees. These surveys also show that the period of most profitableness is when the trees are from 15 to 26 years old in Jefferson County and between 15 and 22 years in Berkeley County, while the peak of production is from 19 to 22 years in both counties. There are trees scattered here and there in these counties that are much older, perhaps as old as 100 years but they are uncommon.

In the mountainous regions of the state there are several orchards which are still profitable at 40 to 50 years of age and some trees may be found which are still bearing at the old age of 75 to 100 years. What is true of this section is also true of the Northern Panhandle of the state. Near Wellsburg, the original Grimes Golden tree lived to be over 100 years old. Apple trees growing along the Ohio River are longer lived than those of Berkeley and Jefferson counties.

As far as the writer has been able to ascertain, the conditions that exist in Virginia and the eastern counties of West Virginia, are found also in those sections of Maryland and Pennsylvania which are included in the Shenandoah-Cumberland fruit district, and it is to this section which lies in West Virginia that attention will be largely given in this paper.

This area lies in the Appalachian Valley region and consists of a series of mountain ridges and intervening valleys which extend in a general northeast-southwest direction. The valleys are broad and fairly smooth while the mountains are narrow, ridge-like, and rise abruptly from the valleys to a height of about 1000 feet. The elevations of this region vary greatly from 275 feet at Harpers Ferry to 2500 feet or more on some of the mountains.

The question now arises why it is that apple trees in West Virginia have a shorter profitable life than those in New York State for instance, or why it is that apple trees in the plateau regions of the Appalachian Mountains or in the northern panhandle of the state live and produce crops from 10 to 20 years longer than those in the Shenandoah-Cumberland District.

To obtain the observations and views of the growers, a ques-

tionnaire was sent out to a number of the men located in the various fruit sections of the state who are actively engaged in and have had long experience with fruit growing. To indicate that the subject of the length of life of apple trees is a live one, fully 98 per cent of all the questionaires sent were filled out and returned. This paper is based largely on the replies received from these growers.

Undoubtedly there are a number of factors which have a great influence on the length of life of apple trees in various sections of the United States, and these may be of material advantage in one respect and a serious disadvantage in another. Among the factors which have an influence on the life of the trees may be mentioned:

1. *Soils*—The soils of the Shenandoah-Cumberland District in West Virginia may be divided into three general divisions or soil provinces, (a) the Limestone Valley province which predominates over the eastern half of the area and is derived from limestone of varying purity, (b) the Appalachian Mountain province which predominates in the western half of the area and is derived from shale and sandstone, and (c) the River Flood Plains province which is found along streams and is made up of old and recent alluvial deposits. Only a small area of the soils in this section belongs to this last province and, as a rule, this is not planted to orchards.

The soil accumulations over the limestone formations are usually shallow, but as a rule are deeper than those of the shales and sandstones. The formations from which these soils have been derived were originally nearly horizontal, but at the time when the land was elevated these formations were folded and are now inclined at varying angles and in some cases outcrop at the surface in narrow belts. The soils of limestone origin are by far the most fertile. The shale soils are known locally as the red, yellow and black shales and rank in fertility in the order named. The black shales are of questionable value for orchard purposes as it is imperative to use large amounts of fertilizers each year if growth or fruit production is secured.

The replies received to the questionnaire show that the fertility of the soil is one of the most important factors in governing the length of life of apple trees and may be summarized as follows: Apple trees planted on the limestone soils are longer in coming into bearing, bear heavier crops of fruit and live much longer than the trees planted on shale or sandstone soils. Many of the growers say there is a difference of 10 to 15 years between the life of apple trees planted on limestone and on shale soils. This is due to depth of soil, original fertility, and ability of the soil to retain moisture and the elements of plant food. The shale soils are shallow—6 to 12 inches in depth and the disintegrated shale beds are encountered just under the surface soils. In the plateau regions of the mountains the soils are clay loams and the soil is deeper with a deep sub-soil which accounts in a measure for the longer life of apple trees in this section. Here the trees that live to be 40 to 75 years old are the ones that have been particularly favored with deep rich soil, and their existence can be accounted for from this standpoint. In the Ohio River and northern Panhandle sections, the soils

are largely alluvial deposits which are relatively deep with a well broken sub-soil, and although not any more fertile than the limestone soils of the Eastern Panhandle, from a grain standpoint, they provide soil conditions more favorable to apple trees. The soils of New York, Michigan, and a large portion of the soils of New England, have been formed by glaciers or by glacier materials and are much more broken up, deeper, and more fertile than are the residual soils of the Appalachian Mountain province. Undoubtedly lack of sufficient soil fertility is probably the most important cause of the short life of the apple trees.

2. *Diseases and Insects*—Diseases and insects are probably next of importance in causing the short life of apple trees in West Virginia. As this state is just on the border between the northern and southern conditions the diseases and insects found in both sections are common to this state and in some cases in their worst forms. The differences in elevation found in the state provide climatic conditions most favorable for the over wintering of various diseases and when conditions are right they spread to the lower valleys, or vice-versa, where more severe damage is done than they would do in their native habitat. West Virginia has practically all of the important diseases and insects affecting apple trees. Several of these, collar blight (Bacillus amylovorus) and various forms of root rot, are the most serious because in the case of trees already planted no practical means of prevention or control have been found. Trees dying from the effects of these diseases are very common and the economic loss caused by the trees being destroyed at the age when they are producing their heaviest crops makes collar blight and root rots of primary importance. Apple scab is spasmodic in its infection; in some years it is bad and in others practically none appears. Scab infections do not take place at approximately the same time year after year when it is present and for this reason scab control in many sprayed orchards has not been entirely satisfactory. Leaf spot, apple blotch, apple rust, crown gall, blister canker and black rot, are the more important diseases causing more or less serious damage to the trees. The work of insects is perhaps as important as that of diseases, but has not been so noticable.

Every reply received to the questionnaire emphasized the great damage done to apple trees by diseases and insects, and it is the unanimous opinion that the short life of West Virginia apple trees is due to a great extent to the work of these parasites. On the poor soils where the resistance is more easily broken down, diseases and insects readily find an entrance and the trees soon succumb.

3. *Rodents*—In sod orchards mice in some instances are a serious pest and destroy large numbers of trees each year. The most serious of these is the pine mouse (Pitymys) because its operations are concealed which permits it to do its damage before its presence is suspected. The annual loss caused by this rodent would amount to many thousand trees.

4. *Climatic conditions*—Apparently climatic conditions in this region are most ideal for fruit growing. The comparatively long growing seasons of warm sunshiny days and an abundance of

rainfall, provide growing conditions most favorable for the growth and fruiting of the trees. These conditions while very favorable for apple trees are also as favorable for the development and reproduction of diseases and insects. The winters are mild and very seldom is there winter injury to even peach trees.

Climatic conditions certainly exert a marked influence on the growth and reproduction of plants as has been found by a number of investigators. Among the climatic factors which have been found to exert an influence on growth and fruiting, are heat and light. It is impossible to say just what the effect of these two factors is on length of life of apple trees as no work to the writer's knowledge has been done. It has been the observation of the writer that the fruits produced by the same variety are considerably smaller when grown in the more northern climates than those grown farther south. To illustrate in another way, York Imperial, Jonathan and Grimes Golden, when grown in the higher elevations of the state are small—so much smaller that they are considered undersized for the varieties. As the rainfall is more in the mountains than in the lower lands the difference must be due to light, or heat, or both. As climatic conditions affect the size of the fruit it is reasonable to believe that it has a definite influence on the length of life of the trees.

It may be that the early and continuously heavy bearing of apple trees in West Virginia may be, in a great measure, due to the peculiar climatic conditions of the state.

5. *Varieties*—The varieties grown now in this section have been selected for quality and early and heavy fruit production. The older, more northern varieties such as Tompkins King, Baldwin, Rhode Island Greening, Northern Spy and others, are as a rule shy bearers, coming late into fruiting, and the season of these varieties when grown on the lower levels may be considered as fall instead of winter apples. On the other hand, the old trees still bearing at an age of 50 years or older as a rule are Baldwins, Rhode Island Greening, Northern Spy, Yellow Newtown, Willow Twig, and other old and little grown varieties, some of which are of southern origin.

From observations, the varieties which come into fruiting early and bear heavy crops each year are short lived. This is probably due to a combination of causes, for example the soils of this state are low in nitrogen and with the long and ideal growing season the trees soon reach the condition where there is an excess of carbohydrates present in proportion to the amount of nitrogen which would cause early bearing. The long growing season would perhaps in the case of bearing trees provide for sufficient food manufacture and storage to produce a crop the second and succeeding years if sufficient nitrogen were present in the soil. Several of the varieties now grown in the Shenandoah-Cumberland district come into bearing at five and six years of age and by the time they are seven or eight years old are producing heavy crops of fruit. Practically everyone answering the questionnaire pointed out that early and heavy bearing of the trees is a very important cause for the short life of the trees. One who gives the record of

his orchard now seventeen years old says, "Trees began bearing when six years old and have borne very regularly, averaging one and a half barrels per tree at seven years old and have never failed except in 1913 and 1921 when killed by frost." Another orchard of 20 acres, 19 years old in 1919 produced 4300 barrels of A grade York Imperial and Ben Davis; in 1920 it produced 4500 barrels of A grade fruit, and in 1921 had bloom for equally as large a crop which was killed by the spring freezes. This is the history of numerous other orchards in this district. Undoubtedly the heavy annual bearing would cause great exhaustion of the trees and soils which if not cared for by the best of orchard management would weaken the trees to such an extent that they would become very susceptible to attacks by disease and insects.

To summarize, the short life of apple trees in West Virginia is primarily due to shallow soils low in the elements of fertility; to great abundance of disease and insects, some of which occur in the worst form; to climatic conditions which seem to be favorable to the rapid development of the trees and in providing in some cases almost ideal conditions for the work of diseases and insects; lastly, to the varieties now grown which come into bearing early and bear each year heavy crops which cause an exhaustion of the fertility of the soil and a weakened condition of the trees.

Notes on the Length of Life of Apple Trees in Minnesota*

By W. G. Brierley, *University of Minnesota, St. Paul Minn.*

THE longevity of an apple tree is determined by many different factors. Selection of sites and varieties and the subsequent care of the trees may be managed in such widely differing ways that trees in some cases will live several times as long as in other cases. In Minnesota, where apple trees are not long lived as a rule, this wide variation in length of life has been recognized for a long time. In the Experiment Station, M. J. Dorsey and C. Haralson have worked for years to develop hardy varieties and to analyze hardiness in the effort to produce longer lived trees.

It is difficult to separate out the effect of climate from other factors affecting longevity. If the varying sites, different cultural methods, varieties, structural weaknesses, and the effects of insects and diseases be disregarded, it will be found that climatic factors, such as severe winter cold, drying winds, and summer drought, take a heavy toll in Minnesota orchards. No systematic study of the life duration of varieties has been attempted, but our Experiment Station workers have estimated 30 years as the average for all varieties grown under our conditions.

In a cost of production survey in Minnesota some intersting

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data on the life of trees were obtained. In 64 orchards included in the survey the range in age was 8 to 36 years (on the basis of 1920.) Only two of the orchards were over 25 years old, and the mean age was 15.6 years. Table I shows the grouping according to age, the number of orchards, and the average in each group for 58 of the orchards surveyed.

TABLE I.

Age Grouping of 58 Bearing Orchards in Minnesota

Group No.	Age of Trees		Number of Orchards	Number of Acres
1	8 to 13		13	83.5
2	14 to 19		34	232.2
3	20 to 36		11	44.1
Mean	15.6	Total	58	359.8

While this table shows that the majority of the orchards considered were planted between 1900 and 1906, it also indicates that the older orchards are few in number. About as many more orchards from 20 to 36 years of age were visited, but could not be included in the survey on account of the poor condition of the trees. To judge from the condition of these older orchards and also of those in group 2, the latter will be failing when ten or fifteen years are added to their age.

The average life history of an apple tree in Minnesota is to commence bearing at 6 to 8 years after planting, reach its maximum production at about 20 years and then gradually fail. Apparently this is due in the main to the effect of climate, or to lack of hardiness. An attempt to round up the opinions of representative orchardists of the state as to the normal length of life of some of the common apple varieties was recently made through a questionnaire. In Table II these replies are averaged and the varieties arranged according to life expectancy, and the figures are from a questionnaire sent to representative orchardists.

TABLE II.

Estimated Length of Life of Apple Varieties Commonly Grown in Minnesota.

Number of Replies	Variety	Estimated Length of Life in Years
62	Hibernal	37.5
71	Oldenburg	35.5
60	Patten	34.3
54	Transcendant (Crab)	34.3
43	Anisim	28.2
70	Wealthy	26.2
29	Florence (Crab)	26.2
64	Northwestern	16.9
74	All varieties	29.0

From this table it appears that none of our common hardy varieties are able on the average to withstand our Minnesota winters for 40 years. The length of life of these varieties is directly correlated with their hardiness, which is expected in a region where severe winters are frequent. That is, we generally admit that a severe climate shortens the life of apple trees and all of these figures support that view.

Some Results of Pruning Investigations With Peaches *

By M. A. Blake, *Experiment Station, New Brunswick, N. J.*

EXTENSIVE pruning investigations with peaches were undertaken by the horticultural department of the New Jersey Experiment Station in 1912, and the results of the first two seasons were published in New Jersey Experiment Station Bulletin 326. A considerable volume of data has been secured since that time and its publication delayed as a result of the war and changes in staff. Some additional facts secured in these investigations and not previously published are therefore offered at this time.

Pruning experiments were conducted at both Vineland and New Brunswick, but the results discussed in this paper are confined to the Vineland orchard. The trees were set in the spring of 1912 and the varieties consisted of Stump, Carman, and Elberta. Peach trees make a vigorous growth upon the sandy loam soils in southern New Jersey and the trees were set 20 x 25 feet apart. The experimental pruning block comprised 150 trees divided into 10 so-called plots with 5 trees of each of the three varieties in each plot. Measurements were made of the entire linear twig growth made by the trees each year and the amount of linear twig growth actually removed from each tree in the process of pruning. The circumference of the trunk of each tree was also measured annually and the yield of peaches recorded as to the number of fruits and the total weight per tree.

There were 5 different pruning treatments as follows: 1. Not pruned. 2. Winter pruned but not cut back. 3. Winter pruned and cut back. 4. Winter and summer pruned, and 5. Summer pruned only. All of the trees including the not pruned were cut back to a height of about 18 to 24 inches when planted. The actual pruning treatments do not begin, therefore, until the close of the first season's growth.

The winter pruned but not cut back treatment consisted of a thinning out of the branches only. The winter pruned and cut back included a thinning out of the branches and some cutting back. The severity or degree of cutting back varies with

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different growers. The attempt was made in these experiments to practice what might be termed a medium amount of cutting back. The winter and summer treatment was intended to be the same type of pruning as practiced in the winter cut back, the difference being that some thinning out of suckers and shoots and the checking of leaders was to be done in summer with the idea of reducing the amount of winter pruning. The summer only treatment was to be the same in type as the winter cut back, and the winter and summer, but all the pruning was to be done in June, July, and the early fall while the foliage was still on the trees.

Comparative Size of One and Two-Year Old Trees

The amount of twig growth made by each tree in the Vineland experiment during the first two seasons was published in Bulletin 326, but this appeared in terms of total linear inches of twig growth only. Since the length of each twig was recorded it is possible to report the number of branches of different lengths made by the trees. It is believed that this information may be of considerable value and three trees each of Stump, Carman, and Elberta have, therefore, been selected to illustrate the number of branches of different lengths developed by the trees during the first two seasons. Trees varying somewhat in size from medium to large were selected in order to give a better idea of the variation which existed.

The majority of the trees developed less than 50 branches of all lengths the first season. There were some exceptions as in the case of the Stump tree with a total of 103 branches. In the case of Stump and Carman about one-half of the total number of branches were 12 inches or less in length.

Table I.

Vineland Peach Experiments
Comparison in Size Between One-Year-Old and Two-Year-Old Peach Trees.

Variety	Season	Tree	Total Growth Inches	Number of Branches 0 to 12 inches	13 to 24 inches	25 to 36 inches	37 to 48 inches	49 to 60 inches	61 to 72 inches	Total
Stump	First	R.16 T.3	640	29	7	9	1	—	—	46
	First	R.19 T.2	773	18	14	9	2	1	—	44
	First	R.25 T.4	1,392	63	26	10	3	1	—	103
	Second	R.16 T.3	4,960	121	96	49	16	1	1	284
	Second	R.19 T.2	5,507	185	117	55	11	—	—	368
	Second	R.25 T.4	7,108	138	140	42	26	7	12	365
Carman	First	R.14 T.5	548	17	14	5	1	—	—	37
	First	R.17 T.2	1,080	17	13	11	4	4	—	49
	First	R.20 T.4	1,177	55	24	2	1	—	—	82
	Second	R.14 T.5	2,676	84	55	23	8	1	—	171
	Second	R.17 T.2	5,060	145	96	31	22	8	—	302
	Second	R.20 T.4	5,088	214	118	30	9	3	—	374

Elberta	First	R.18	T.5	542	8	18	6	—	—	—	32
	First	R.21	T.2	619	9	14	5	4	—	—	32
	First	R.15	T.4	669	36	18	2	1	—	—	57
	Second	R.18	T.5	2,498	89	69	21	2	—	—	181
	Second	R.21	T.2	5,258	215	123	27	17	—	—	382
	Second	R.15	T.4	3,956	140	87	19	11	6	2	265

The gain in growth the second season over the first is very marked commonly amounting to from five to seven times that of the first and the total number of branches increased from less than 50 with the majority of the one-year-old trees to from about 200 to a little less than 400 with the majority of two year-old trees. In most instances one-half or more of the total number of branches were 12 inches or less in length. Some growers make it a practice to cut back all twigs of one season's growth that exceed a certain length. These figures would enable such a one to get some idea of the number of cuts which one would be obliged to make per tree in such pruning. The results in Table 1, for example, indicate that with two year old Stump trees from about 4900 to 7100 inches in size, one would need to make at least from 50 to 75 cuts if all branches, more than two feet in length, were to receive a tipping back. This is a practical suggestion of how the cutting back treatment requires more time than a simple thinning out pruning.

Amount of Twig Growth Removed by Pruning.

It is quite a common recommendation that the annual growth of young peach trees be cut back one-half to one-third of its length annually. The experiments at Vineland indicate that if a proper thinning of branches is practiced with such a cutting back of two-year-old trees, that actually more than 65 per cent of the total annual twig growth is removed. The recommendation that from one-third to one-half of the twig growth be cut back is apt to mislead one into the belief that only about 30 to 50 per cent of the total twig growth is actually removed. The effect of pruning as severe as this will be discussed later.

Yields the Third Summer

Under ideal conditions for growth and fruiting, precocious varieties of peaches like Carman and Stump may produce a considerable quantity of peaches the third summer after planting, in southern New Jersey.

Table II

Growth and Yield of Individual Unpruned Carman Trees—Vineland 1914

Plot	Tree	Total Growth	Yields Pounds	Yields Ounces
1	Row 2 Tree 2	5,728	41	8
	Row 2 Tree 3	2,569	55	4
	Row 2 Tree 4	2,627	41	14
	Row 2 Tree 5	1,571	19	8
	Row 20 Tree 2	5,331	87	4
	Row 20 Tree 3	2,929	58	0
	Row 20 Tree 4	5,088	93	14
	Row 20 Tree 5	4,515	71	14
Average,	8 trees	3,795	58	8

It would be expected, however, that the relative size of the tree would have considerable influence upon the amount of fruit produced. Before discussing the effect of the pruning upon the yields, it is of interest to note the relative production of trees of different sizes in the experiments. Unpruned trees offer the best basis for a comparison of this sort and so the yields of the unpruned Carman trees are submitted in Table 2.

The number of unpruned trees in the experiments was limited and it would, therefore, be unwise to draw conclusions too sweepingly, but some facts appear to be established. Attention should be called to the fact, first, that the trees in row 2 were near the edge of the orchard and for some reason did not produce as heavily in proportion to their size as the trees in row 20, but they are comparable with each other. Large two-year old trees exceeding a total of 5,000 inches of twig growth, may produce from a little less than two to more than three 16 quart baskets of fruit per tree the third summer in districts as favorable as Vineland. Carman trees with about 2500 inches of growth may produce about 2 baskets of fruit, but those with a total growth of much less than 2,000 inches are not likely to produce as much as a basket. One tree with a total growth of 1571 inches produced less than 20 pounds of fruit while a tree making a total growth of 5088 inches the second year produced over 90 pounds of fruit the third summer. The relative size of the trees at the close of the second season does, therefore, have a very marked effect upon yield the third summer and it would evidently pay one well to give the trees thorough culture the first two seasons in districts where peaches come into bearing young. Proper culture to encourage vigorous growth is no doubt equally profitable in other peach districts even though the returns may not be forthcoming until the fourth summer.

Effect of Pruning upon Yields

The nature of the different pruning treatments was described previously. Before discussing the general effects upon yields, however, a statement should be made as to the proportion of the actual growth removed by the different treatments. The winter and summer and the summer only treatment will only be discussed briefly at this time, so that the effect of different degrees of pruning is confined to the dormant season treatments. It was found that a light to medium thinning out pruning of Stump at the close of the second season's growth removed an average of 49 per cent of the annual growth. It amounted to 44 per cent in the case of Carman and 49 per cent in the case of Elberta. Some thinning out and cutting back of all the more vigorous twigs as practiced in the winter cut back treatment actually removed an average of 72 per cent of the annual growth of Stump, 66 per cent of Carman, and 69 per cent of Elberta.

Yields of fruit may be recorded in several ways including number of fruits per tree, pounds of fruit per tree, or pounds of fruit or packages per acre. On the acre basis, or in terms of 100 trees, one gets a better idea of the commercial effect of any treatment. The yields of Carman the third season at Vineland are

presented in terms of 16 quart baskets and 100 trees per acre. A common planting distance for peach trees in the Vineland section is now 20 x 20 feet which means approximately 100 trees per acre. The number of trees in the experimental pruning block was slightly less than 100 trees per acre, but there is no doubt that equally large yields would have been obtained per tree the third summer if the trees had been set 20 x 20 instead of 25 x 20 feet. In fact, this was true in another portion of the orchard where trees were set 18 x 20 feet apart.

The percentage of growth removed per treatment and the effect upon the yield of the three varieties Stump, Carman, and Elberta is given in Table 3. It may be noted that all forms of pruning reduced the total yield of all varieties somewhat and

TABLE III

Per Acre Yields of 16 Quart Baskets of 2½ Pounds Each in Vineland Pruning Experiments Third Summer After Planting. 191¼ Figured on Basis of 100 Trees per Acre

Treatments	Per cent Growth Removed	Average Three Varieties	Stump	Average Circumference Inches	Carman	Average Circumference Inches	Elberta	Average Circumference Inches
Not Pruned, ...	0	190	180	7⅝	247	7¼	98	8⅛
W. N. C. B., ...	47	118	112	7⅞	178	7¼	65	8⅜
W. C. B., ...	69	76	47	8¼	157	7¼	27	9
W. & S., ...	61	110	97	8	186	7¼	53	8⅝
Summer.	46	101	79	8¼	214	7¼	28	8¾

Size of Peaches in Various Packs (Georgia Crates)

Circumferance	Circumference
7¼ inches—10-10-10 pack	8 inches—8-7-8 pack
7½ inches— 9- 9- 9 pack	8¼ inches—6-6-6 pack

particularly of Stump and Elberta which do not fruit quite as freely when young as Carman. The reduction in yield is particularly marked in the winter cut back treatment where the average total growth removed amounted to 69 per cent. These results are in agreement with others obtained elsewhere in the case of apples that dormant season pruning in any considerable amount tends to delay fruiting and to reduce the total yield. However, one should not jump to radical conclusions at a first glance at these figures and decide, for example, that no pruning is the best practice. A study of the yields shows that the degree or the amount of pruning is of more influence than the form and that while the removal of about 46 or 47 per cent of the growth reduced the yield somewhat, a removal of 69 per cent reduced it very markedly. We might well, therefore, inquire into the question

of whether a little lighter pruning than 46 per cent might not give us all the benefits that we might hope to obtain from pruning without reducing the yields.

As previously noted the percentage of growth removed in pruning each tree was recorded as well as the yields of fruit, and since all trees were not pruned in exactly the same degree, it is possible to secure some light on this point by another grouping of the trees in another tabulation. Table 4 shows the effect of different degrees of pruning upon the yields of Carman the third summer.

There was only one tree in the experiment which had as little as 20 per cent of growth removed, and this apparently did not materially reduce the yields. In fact, five trees having an average of 35 per cent of the growth removed produced nearly as well as the unpruned trees, and the removal of an average of 44 per cent on seven trees did not very materially reduce the yield, and this small amount was probably offset by a slight increase in the size of the fruit. The results in the table plainly show, however, that a degree of pruning amounting to 66 or more percent of the actual total growth, did very remarkably reduce the yield the third season at Vineland. The reductions indicated in yield in Table 3 as a result of the different pruning treatments are, therefore, not as serious as a practical grower might at first imagine. It is possible to do a certain amount of pruning without reducing the yields to any appreciable extent. In regions where the trees do not produce fruit the third season, one can of course prune as severely as he may desire without reducing the crop yield 100 or more baskets per acre. The Vineland experiments have shown that a light cutting back at the close of the second season's growth will give just as satisfactory results in tree development and training as very severe pruning and may enable one under ideal conditions, to harvest a considerable crop of fruit.

TABLE IV

Effect of Different Degrees of Pruning Upon the Yield of Carman

Per cent Pruned 1913	Number Trees	Actual Average Per cent Pruned	Average Growth Remaining	Average Yield Pounds	Average Yield Ounces
Not Pruned, ...	7	0	3,795	58	8
1-20, ...	1	20	2,218	53	14
31-40, ...	5	35	2,365	53	9
41-50, ...	7	44	2,647	51	1
51-60, ...	5	54	1,942	48	4
61-70, ...	7	66	1.377	33	9
71-..	3	76	1,075	25	8

Size of Fruit Produced Under the Different Pruning Treatments

The profit obtained from an acre of peaches is not determined solely by the total quantity of fruit produced. The size and color of the individual fruits may be most important factors. The average circumference of the fruits secured under the different pruning treatments is therefore, included in Table 3. These figures were secured by counting the total number of fruits per tree at picking time and recording the total weight. From these figures was obtained the average weight per fruit and this was changed into terms of circumference by means of a table of weights and circumferences secured for Carman and published in New Jersey Station Bulletin 284. In later years the entire crop of fruit from the different trees was sized by means of a mechanical sizer.

The Carman peaches were all picked as soon as they reached shipping condition which did not permit them to develop fully any differences in size which might have occurred and they average extremely uniform. The fruit upon Stump and Elberta was allowed to reach a more advanced degree of maturity and some differences in average size of fruit appear.

A severe pruning such as the winter cut back treatment of 69 per cent in the case of Stump increased the average circumference of the fruits five-eighths of an inch over the not pruned trees, but reduced the yield at the rate of 133 baskets per 100 trees. Stump peaches 7⅝ inches in circumference are a good medium commercial size, while 8¼ inch peaches are exceptionally large. The latter, however, would not bring enough more money per basket sold in quantity to make up for the difference in quantity. The same would hold true for Elberta.

The color of the peaches upon the not pruned and the more lightly pruned trees was fully equal to and sometimes better than upon the severely pruned trees. In other words, the pruning of young peach trees can be overdone.

Size of Fruits Largely Influenced by the Number of Specimens on the Tree

As was the case with the general figures on yield of peaches per pruning treatment in Table 3, the general figures on average size of fruits suggest a study of this from the standpoint of different degrees of pruning and this is provided in Tables 5 and 6. A study of the individual Stump trees in the not pruned, winter not cut back and the winter cut back treatments, permits of a comparison of the effect upon size of fruit of different degrees of pruning from no pruning to a removal of 84 per cent of the annual growth.

It may be noted from the figures in Table 5 that in general the size of the fruits tended to increase with the severity of the pruning, but only as the number of fruits per tree were accordingly reduced. Row 16, tree 4, with 64 per cent of the growth removed produced larger peaches than row 25, tree 4, with 84 per cent of the growth removed. But the latter tree matured 103 peaches in spite of the heavy pruning while the former produced only 69 specimens.

The not pruned plot also furnished some convincing evidence that the number of fruits per tree largely determines the size provided that normal growing conditions occur. The unpruned trees in row 1 set relatively few fruits and the size was accordingly large in comparison with that from the trees in row 2 which carried more than 200 specimens each. The following summary is drawn from Table 5.

Up to a total of 63 specimens per tree the circumference of the fruits was 8 inches or more. When the number ranged from 70 to around 200 specimens per tree the average size was 7¾ inches. From 225 to 240 specimens per tree resulted in fruits at least 7⅝ inches in circumference while one tree carried 384 specimens

TABLE V

Effect of Degree of Pruning on Size of Fruit of Stump at Vineland in 1914

Treatment	Tree	Growth Inches Per cent	Pruned Off	Number of Fr	Average Circumference	Yield Pounds	Yield Ounces
Not Pruned, ...	Row 19 Tree 2	5,507	0	240	7⅝	58	14
	Row 19 Tree 3	4,267	0	225	7⅝	55	8
	Row 19 Tree 4	5,061	0	384	7½	91	13
	Row 19 Tree 5	3,682	0	423	7⅜	93	4
	Row 1 Tree 2	3,175	0	67	7⅞	18	4
	Row 1 Tree 3	2,302	0	7	8¼	2	2
	Row 1 Tree 4	5,014	0	57	8¼	17	14
	Row 1 Tree 5	2,827	0	37	8	10	10
W. N. C. B., ...	Row 16 Tree 3	4,960	29	254	7¾	66	8
	Row 4 Tree 5	3,980	42	70	7¾	18	8
	Row 4 Tree 2	4,739	45	63	8¼	19	8
	Row 16 Tree 2	4,707	54	129	7¾	33	12
	Row 4 Tree 3	2,110	55	3	8	0	14
	Row 16 Tree 5	3,737	55	114	7¾	30	0
	Row 16 Tree 4	5,758	64	69	8	19	6
W. C. B., ...	Row 13 Tree 3	3,431	61	15	9	6	4
	Row 13 Tree 5	4,559	64	58	8¼	16	15
	Row 25 Tree 3	2,964	66	37	8⅝	12	12
	Row 25 Tree 2	3,306	73	14	8⅜	4	9
	Row 13 Tree 2	4,925	71	20	8¼	5	15
	Row 13 Tree 4	4,586	76	13	8	3	10
	Row 25 Tree 4	7,108	84	103	7¾	26	6

TABLE VI

Effect of Degree of Pruning on Size of Elberta Fruit at Vineland in 1914

Treatment	Tree	Growth Inches	Per cent Pruned Off	Number of Fruits	Average Circumference	Yield Pounds	Yield Ounces
Not Pruned, ...	Row 3 Tree 2	4,141	0	44	7⅜	10	15
	Row 3 Tree 3	3,002	0	4	8⅛	1	5
	Row 21 Tree 2	5,258	0	109	8⅜	37	13
	Row 21 Tree 5	3,249	0	131	8¼	44	9
W. N. C. B., ...	Row 6 Tree 5	2,746	35	19	8¼	6	10
	Row 18 Tree 5	2,498	42	119	8⅜	41	11
	Row 6 Tree 2	3,076	45	38	8¼	13	0
	Row 6 Tree 4	4,208	49	34	8⅝	13	2
	Row 6 Tree 3	1,466	50	12	9	5	1
	Row 18 Tree 3	2,315	54	47	8¼	16	2
	Row 18 Tree 2	4,931	59	46	8	14	8
W .C. B., ...	Row 15 Tree 3	2,665	56	19	8⅞	7	14
	Row 27 Tree 5	5,311	58	12	9¾	6	13
	Row 27 Tree 4	3,350	59	11	9	4	11
	Row 15 Tree 5	2,558	66	12	8½	4	6
	Row 27 Tree 3	1,885	69	—	—	—	—
	Row 27 Tree 2	4,819	75	23	9¼	10	8
	Row 15 Tree 2	3,343	76	6	8⅝	2	5
	Row 15 Tree 4	3,382	84	23	8⅝	8	15

for an average size of 7½ inches and another 423 specimens for an average circumference of 7⅝ inches. Where the number of fruits upon a tree is very limited the average size may be influenced in considerable measure by their location on the tree.

In spite of some variation between individual trees which is normal and to be expected this table points out clearly the fact that to greatly increase the size of the fruits above medium it is necessary to greatly reduce the number of specimens. Failures to secure satisfactory results in size as a result of thinning peaches are probably due in a large measure to the fact that the thinning is too light. These figures also make it appear possible to determine the approximate number of fruits which a tree of a definite variety and size can mature to a given average circumference under normal conditions. It is a well-known fact of course, that peaches tend to average larger in some seasons than in others because of variations in growing conditions.

Some varieties such as Elberta tend to produce fruits of larger size than others. A study of Table 6 shows that the Elberta trees at Vineland the third summer were able to mature up to 131 specimens per tree to a size of 8¼ inches as against less than 70 in the case of Stump.

RESULTS APPLY ONLY TO TREES IN THE THIRD SUMMER'S GROWTH AFTER PLANTING

In submitting these preliminary data the author realizes the danger that some may apply it to peach trees of all ages and are

likely to be led astray, but additional information is needed by many as to the pruning of two-year-old peach trees in districts where the trees sometimes come into bearing the third summer after planting. No one should be led to think that pruning should be discontinued the second season, neither should vigorous, well-grown two-year old trees of a variety like Carman be cut back too severely if a crop is to be secured the third summer.

Thirty-five to perhaps forty per cent of the total annual growth can be removed without greatly reducing the yield. A cutting back of the branches one-third to one-half of their length, however, reduces the annual growth more than 65 per cent and is of doubtful economy.

Some Relations Between Circumference and Weight, and Between Root and Top Growth of Young Apple Trees

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An opportunity presented itself in connection with experiments involving a large number of young apple trees to learn more about the relationship between circumference of trunk and total growth. It seemed especially desirable to gain some idea regarding the reliability of such an index as a measure of response in growth when relatively few individuals are involved. Certain other relationships exhibited by these trees are also discussed in this paper.

Material and Methods

The trees used in this study were of the variety McIntosh propagated by benchgrafting. They had been set out as one year whips in the spring of 1917 on an artificially drained, heavy loam soil. The trees were distributed in 30 plats, each of which was one-hundreth of an acre in size. All plats had 2 rows of 10 trees planted at intervals of 4 feet and they were separated by a buffer row of trees planted at the same distance. In all cases the rows were 4 feet apart. Selection of the trees was done in such a way that the average vigor and the coefficient of variability was the same for every plat at the beginning of the experiment. After planting, all trees were cut back to 4 inches from the surface, and only one sprout was permitted to grow and form the trunk. No other pruning was done during the 4 years of the experiment.

After each season's growth, the circumference of the trees was measureed at a marked region about 10 cm. above the surface. In the spring of 1921 before the buds began to swell, the tops of the trees were cut at the surface and weighed to the nearest 10 grams. At this time the height and spread of the trees were also recorded to the nearest one-tenth of a foot. Later in the

spring, the root systems were dug, care being taken to remove from the soil all roots larger than 0.3 cm. in diameter. The underground portion of the trunk of the tree was cut from the root system proper at the graft union, and its weight was added to that of the top. In the few cases where they occurred, cion roots were included in the weight of the root system. The length of the underground portion of the trunk served to indicate the depth of planting.

Relation Between Circumference and Weight

An inspection of the data showed wide variations in weight between trees of the same circumference. For example, 20 trees with a circumference of 14.0 cm. had an average weight of 5306 grams with extremes of 4170 grams and 7860 grams, and a coefficient of variability equal to 14.2 per cent. In order to learn something of the average relation between girth and size, the data from all trees were arranged in descending order of weight, and these weights together with the corresponding girths were averaged in lots of 5, 10, 20, and 40. These average values were then plotted with the circumference along the abscissa and the weight along the ordinate. A smooth curve was obtained by connecting the points representing averages of 40, but with the smaller lots the line was more or less zig-zag. It should be pointed out that such a curve would not coincide with a curve derived mathematically from the same data, but it would probably be close enough for our purpose. According to the curve the relation between the circumference and the weight in this particular lot of trees was such that the weight was increased approximately 7.3 times while the circumference was doubled. This relation, no doubt, would vary with the variety, age, soil and other factors.

The nature of the relation is such that the smaller trees are given an undue weight in the average, unless the coefficient of regression is taken into consideration. This is shown by the fact that the average weight of the 20 dissimilar trees of any plat, or of the 3 or 4 plats having the same treatment, is always greater than the weight that would correspond on the curve to the average circumference of the same trees. For example, 80 trees on 4 plats receiving the same treatment had an average weight of 3054 grams and an average curcumference of 11.2 centimeters. According to the curve, trees with this circumference should weigh only 2780 grams. The results indicated by the girth are, therefore, about 91 per cent of the actual weight.

In order to reduce the error due to averaging widely varying individuals, groups of about the same size were obtained by arranging the trees in each of the various plats according to weight and then averaging in groups of five. In such cases the points for average weight plotted against circumference fell above, below, or on the curve. The calculated weight corresponding to average girth varied from 0.66 to 1.26 times the actual weight, but 75 of the 108 groups were within 10 per cent of the true value. A study of the data at hand gives no clue to account for wide deviations from the average relation between the girth and

total weight as indicated by the curve. The explanation is apparently not to be found in the rate of growth, the height and spread of the top, the depth of planting, or the influences of soil management.

In order to emphasis the need of care in interpreting circumference measurements, especially when small differences are concerned, lots of 5 trees each from the same plot grouped as above, were compared on the basis of actual weights, and also on the basis of weights corresponding to girth according to the curve. These girth equivalent weights varied from actual weights by less than 10 per cent of the true difference in only 18 of the 81 cases: by more than 10 but less than 25 per cent in 23 cases; by more than 25, but less than 50 per cent in 22 cases, and by more than 50 per cent in the remaining 18 cases. The difference between the values from actual weight and from the weight corresponding to girth was usually greatest when the difference between groups was small.

The relation between circumference and weight of top was found to be subject to the same fluctuation as described for the relation between circumference and weight of the entire tree.

It appears, therefore, that even though the coefficient of corelation between girth and size is high (Tufts 1919), the relationship is of such a nature that circumference measurements are reliable as a measure of small differences, only when rather large numbers of approximately similar trees are concerned in the average. Circumference records might nevertheless be very useful for measuring the growth of the same tree from year to year. Such records, as will be shown later, would probably be a more reliable index of growth than average twig lengths.

Relation Between Weight of Top and Weight of Root

The value obtained by dividing the weight of the top by the weight of the root varied from 0.89 to 4.44, the average being about 2.00. The depth of planting as indicated by the length of the underground stem portion seemed to be one of the factors affecting this ratio. Each plat was divided into 2 lots; the one composed of the 10 trees having shallow root systems, the other of the remaining 10 trees with relatively deep root systems. It was found in every plat that the more deeply planted trees had the smaller root system in relation to the top. Summarizing all cases the following averages were obtained.

Number Trees	Depth Cm.	Weight Trees grams	Weight Roots grams	Weight Tops grams	Top ÷ Root
290	8.7	3,460	1,240	2,220	1.87
290	15.0	3,450	1,090	2,360	2.18

These figures indicate that a root system on deeply planted trees compared with roots of the same size on shallow planted trees, will produce a top about 22 per cent heavier. The total weight of the tree, however, has not been influenced by the depth of planting.

Naturally, there are cases that do not follow this average behavior. The trees with the deepest root systems do not always show the highest ratio, and some shallow planted trees have root systems that seem too small for their depth. A possible explanation for some of these cases was suggested by Chandler's work (1919), in which he showed that an unusual rate of top growth such as might be caused by nitrogenous fertilizers or by pruning will temporarily result in a relatively small root system. A study of the data seemed to indicate that the height and spread of the tops also influenced this relation between weights of top and roots.

Out of the 129 cases in which the ratio seemed too high for the depth, 30 per cent had especially tall, but narrow trees for their weight; 22 per cent made more than average growth as indicated by the percentage increase in circumference during 1920; 29 per cent were evidently influenced by a combination of these two factors. The remaining 19 per cent of such deviations could not be accounted for in any of these ways. Out of 89 cases in which the ratio seemed too low for the depth, 24 per cent were short, spreading trees; 33 per cent had made sub-normal growth during 1920; 19 per cent were associated with a combination of low trees and slow growth, while the remaining 24 per cent of the cases could not be reconciled by the data at hand. A few examples will serve to show the nature of these influences on the relationship between top and root.

Number	Depth C. M.	Top ÷ Root	Gain in Girth per cent	Spread feet	Height feet	Height ÷ Spread
1 a, ...	8.0	1.38	41	4.6	7.6	1.65
1 b, ...	5.0	1.73	41	4.4	9.0	2.05
2 a, ...	9.0	1.31	33	4.3	8.1	1.88
2 b, ...	6.5	1.86	43	4.2	8.2	1.95

The unusual ratios in 1a and 1b are associated with a difference in the height of the tree; in 2a and 2b with a difference in the rate of growth. The trees in these cases weighed approximately 5000 grams.

The question might arise whether the ease of digging would influence this ratio, the assumption being that all roots on shallow planted trees could easily be removed, while some of those on the deeply planted trees might be lost on account of the difficulty of

digging. Only very few roots, however, went deeper than 2½ feet below the surface, and in such cases the weight of the unremoved portions of the roots was estimated by substituting a full length root having the same diameter. The weight of such roots was a very small part of the total weight and, even if omitted entirely, could have had but little influence on the ratio. Furthermore, the weight of the underground portion of the trunk could have but little effect on the ratio since in the deepest trees it accounted for only 6 per cent of the total weight of the top.

In general then the deeply planted trees appear to be more efficient in-so-far as a greater proportion of the food remains in the stem portion. More uniform moisture conditions at the lower depth would probably be among the factors which would afford an explanation for this relation. Relatively tall trees grow somewhat later than those with low, spreading tops, and consequently a shorter time could remain in the former case for late root growth, or for the accumulation of food. When the trees are making a poor top growth there is more chance for the food utilization or storage in the root system. This would probably account for the relatively heavy roots on slow growing trees even though they are deeply planted.

The Relation Between Top and Root as Influenced by Cultural Methods

It has been observed by several investigators that trees growing in competition with grass have a relatively heavy root system as compared with those under cultivation. This condition also held for the young McIntosh trees planted in sod without applications of nitrogen. The average ratios between root and top for the 20 trees in each of the sod plats were 1.88, 1.80, and 1.54, as compared with 2.11, 1.98, 1.69, for corresponding cultivated plats, the plat averages being 1.74, and 1.93 respectively. But when the sod trees each received one-half pound of sodium nitrate, this relationship was this reversed, the ratios being 2.09, 2.35, 2.15, and 2.26 for the sod plats, as compared with 1.81, 2.13, 2.09, and 1.77 for the corresponding cultivated plats, the plats averaging 2.21 and 1.95 respectively. Even though the sod trees weighed only three-fifths as much as the cultivated trees they were actually taller than the latter. The spread of the branches in these sod trees, however, was only two-thirds as much as that of the cultivated trees. The ratios between the spread and height were 2.83, 2.81, 2.60, and 2.45 for the sod, as compared with 1.98, 1.82, 2.00, and 1.82 for the corresponding cultivated plats.

It is plainly evident to the casual observer that the average length of new growth on the sod trees for 1920 was greater than that of the cultivated trees. But the cultivated tree had many more active growing points, while a large percentage of the buds on the vigorous sod trees remained dormant giving the characteristic long bare branches. Apparently the so called inhibitor which is supposed to prevent the growth of many lateral buds when there is active terminal growth, is largely neutralized, or otherwise made less effective by cultivation, or more likely, cultivation

supplies the necessary growth-producing substances which enable the buds to become active. The result in either case is a round top tree with many branches as compared with the tall spindling growth of sod trees invigorated by sodium nitrate.

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Possible Cause for Variation in Yield of Check Plots in a Fertilizer Experiment With Vegetables

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CHECK plots are generally considered indispensable in field experiments. Their usefulness depends upon the degree to which their yields truthfully reveal soil variations, and upon the extent to which the soil of treated plots can be depended upon to resemble that of the check plots. Variation of check plot yields is expected, but the causes are not usually determined, although it appears evident that, in the interpretation of the results of an experiment, the causes of soil variation are as important as the yields themselves.

Description of the Experiment.

The experiment under consideration is listed in the "Classified List of Station Projects carried on by the Agricultural Experiment Stations" (1920) under the title "A Study of the Fertilizer Requirements of Cabbage and Tomatoes." It was begun in 1917, and involves a total of 408 plots one one-hundredth acre in size, with an untreated or buffer strip half the width of the fertilized plots between each pair of the latter. The treated plots are each twelve feet wide and thirty-six feet four inches long, and they are arranged in sections which, with the included check plots, consist of 102 plots each. Each section has a different crop in any one year. The sections in their turn are divided into six strips or tiers, separated by sod lanes, each tier having seventeen plots. Of these seventeen, Numbers 1, 5, 9, 13, and 17 are untreated checks, all the others receiving fertilizer or manure. Thus every fourth plot is a check plot, and it has been the custom to correct the observed yields of the fertilized plots by assuming uniform changes in soil from one check plot to another. Since some of the treatments are used on but one plot for each crop, and with one exception no treatment is repeated more than twice, the importance of the check plot in this experiment may be clearly seen.

The rotation practised in this test begins with early cabbage, which is followed by early potatoes, tomatoes, and clover. The cabbage and tomato crops are fertilized, the potato and clover crops receiving no treatment. It has been the practice to plant rye, or rye and hairy vetch, in the fall after the three cultivated crops, but the growth has not always been satisfactory. The check plots have received no fertilizer or manure of any kind, but they have been seeded with the winter cover crops. Growth of rye and vetch has in recent years been almost negligible on these plots. The soil involved in this experiment is generally classed as Hagerstown silt loam, although some of the plots evidently are occupied by clay loam. As farm land this type is recognized to be well drained, highly productive and one on which a prosperous agriculture can be built up.

Throughout the progress of this experiment the variation in yield of check plots has been carefully noted. Apparently the difference between the most and least productive check plots has become greater from year to year, and in 1921 some of the plots on which cabbage was planted yielded no crop whatever, while others yielded several tons per acre. Obviously, a wholly unproductive check plot is of little value, and, therefore, it seemed wise this fall to look for the causes that brought about these extreme variations in yield, so that the utility of the check plots might be determined once for all.

Accordingly, in the fall of 1921 when the yields of all sections had been recorded, seven pairs of check plots were selected for study, the basis for selection being the size of the crops grown on these plots since the beginning of the experiment. Each pair consisted of two plots lying in the same tier, one noticeably more productive than the other when all the crops grown were considered. Including the timothy and clover crop which preceded the first cabbage crop on each section, and which was weighed plot by plot, and including also on Section B partial records for a rye cover crop in 1921, the crops grown on each section have been as follows:

	Section A	Section B	Section C
1916	Timothy and Clover		
1917	Early cabbage	Timothy and clover	
1918	Early potatoes	Early cabbage	Timothy and clover
1919	Tomatoes	Early potatoes	Early cabbage
1920	Grass	Tomatoes	Early potatoes
1921	Early cabbage	Rye cut for grain, Clover	Tomatoes

Section D is not considered in this paper.

The first notes were made upon the depth of the surface soil and upon the character of the subsoil to a depth of thirty-six inches in the check plots selected for study. Observations were made at two points in each plot. In only three of the fourteen plots were the

two measurements of surface soil depth within one-half inch agreement with each other, while two plots showed over two inches of difference in depth of surface soil between the two points of observation, not over twenty-five feet apart. The average depth for all the better plots was 7.9 inches, for the poorer plots 7.8 inches. Both the greatest and least depths of soil were found among the latter. Apparently depth of surface soil is a secondary factor in the problem.

In the subsoils there was even greater variation than in the surface soils, or perhaps the differences were only more evident because the blackness of organic matter did not mask them. In no case was bed rock found within three feet, although the indications were that bed rock approached as close as four feet to the surface in some plots. In almost every plot noticeable differences, of a character likely to affect crop growth, were found between the two points examined. On one side of one plot very wet, plastic clay was found at thirty inches, although Hagerstown soil is normally well drained. In another case the soil auger could be thrust down with no turning to a depth of thirty inches, there being almost a cavity under the surface at this point. This could not be done within one foot of that particular spot on any side. There were conspicuous variations also in the color of the subsoils, they being yellow in some cases, deep red in others, with various proportions of the two colors prevailing in the several plots. The deep red color is generally found, under this soil, rather close to bed rock. In fact, the inevitable conclusion drawn from the subsoil examinations was that, although bed rock was not found anywhere within three feet of the surface, yet it probably contributes largely to the variation in drainage and composition of the soil layers above it. On Hagerstown soil a subsoil and bed rock map appears to be a prerequisite to a full understanding of the behavior of crops.

Laboratory samples of both surface soils and subsoils were taken, composite samples being made from the two borings in each plot. They were air dried and sieved through a two-millimeter sieve.

Tests were run on all samples to determine the content of humus soluble in dilute ammonia, and other tests to determine the loss on ignition, because it was thought that the content of organic matter might partly explain the behavior of the crops during the rather dry season of 1921. Neither of these tests is today considered wholly reliable, but they were accepted in the present instance as showing accurately enough the relative content of organic matter in the samples.

In five of the seven pairs of soils, the more productive soil showed the greater amount of humus; in one pair the percentages were practically the same, while in the seventh pair the poorer plot showed the more humus. The greatest range in any pair was from 1.970 to 1.260 per cent.

The results of the tests for loss on ignition roughly paralleled those for humus centent. The greatest difference in any pair of plots amounted to two per cent, the more productive plots showing 6.1 per cent loss, the less productive 4.1 per cent. Neither

of these tests furnished a satisfactory explanation of the variation in yields, since the question at once arose, "If content of organic matter is the immediate cause of yield fluctuations, what has caused the variation in organic matter?" The colors of the residues left after ignition indicated that the mineral composition of the surface soils differed greatly among the plots. The color differences were largely concealed in the unburned soils.

Two soil acidity tests were run on all the samples, and it is thought that they have revealed the principal cause of yield variation. The first was a Jones test, as modified by White; except for the use of a shaking machine, this is the method now most frequently used for soil acidity in the laboratory of the Division of Soil Technology, Department of Agronomy, at the Pennsylvania Station. The Hopkins method also was modified, chiefly by reduction to forty grams of the amount of soil used, with a corresponding reduction to 100 c. c. of the amount of normal potassium nitrate added, and the use of a shaking machine for one hour in place of the usual shaking by hand and settling over night.

The comparative lime requirement of the plots is shown in the following table, in which the requirement is given in pounds of calcium oxide required by an acre of soil, estimated to contain two million pounds.

Productive plots			Less productive plots		
Plot	Jones	Hopkins	Plot	Jones	Hopkins
A-1-5, ...	1,000	158	A-1-17	2,599	1,118
A-3-5, ...	2,740	311	A-3-13	3,085	673
A-6-9, ...	4,565	627	A-6- 5	3,272	753
B-3-5, ...	2,783	667	B-3-17	2,884	747
C-1-13, ...	2,650	321	C-1- 5	3,028	564
C-4-17, ...	2,282	452	C-4-13	2,527	569
C-5 9, ...	3,074	329	C-5- 5	3,121	432

It will be noticed that in six of the seven pairs of plots the Jones method showed a greater lime requirement for the less productive plot, the exception being Plots A-6-9 and A-6-5. In all cases the Hopkins method showed higher lime requirement for the less productive plot, the largest difference in any pair being in the pair A-1-5 and A-1-17. The latter is the lowest of all the plots tested in both humus content and loss on ignition, and in 1921 produced less than 200 pounds of cabbage per acre, whereas its companion plot produced at the rate of 7600 pounds per acre. The texture of the soil on the plots, however, has some influence on the yields, since the soil of Plot A-1-17 has a large amount of clay resembling that usually found in the subsoil of Hagerstown silt loam.

The divergence between the two tests is not unusual, but it is significant in the present instance because the Hopkins test has recently been declared by Mirasol, working at the University of Illinois, to be an accurate indicator of the amounts of soluble aluminum in soils. He states, "Veitch had demonstrated that the Hopkins method does not bring considerable free acid in an acid

soil into solution, but instead brings the aluminum in the soil into solution; the application of the method to field conditions has given excellent results. In other words, the method determines aluminum. The application of limestone to acid soils according to the method, eliminates the effect of aluminum, and so far as aluminum is concerned in acid soils, the Hopkins method is the best for determining and correcting soil acidity."

The evidence points strongly to the presence in the soil of these Pennsylvania plots of either soluble aluminum or iron, which substances have been found by various investigators to be toxic to many kinds of economic plants, though Hartwell has found, not equally toxic to all of them. True, the evidence as yet is entirely circumstantial, but it is convincing. The following facts are especially interesting in this connection:

1. It has been found in Pennsylvania that lime requirement tests by the Veitch method give relatively high requirement for the Volusia soil as compared to the Hagerstown. In farm practice, however, less lime is often needed on Volusia soil to get good growths of clover than on the Hagerstown soils, which have an indicated lime requirement of only 683 pounds of calcium carbonate as compared to 4833 pounds for the Volusia soils. Observation, not yet supported by careful tests, leads to the belief that the relative amounts of soluble aluminum or iron, not shown by the Veitch method, have brought about these differences in practical lime requirement.

2. The researches of Abott, Conner, and Smalley at the Indiana Station, of Hartwell and associates in Rhode Island, and of Mirasol in Illinois, tend to emphasize the importance of the soluble salts of aluminum as the cause of many crop failures. Lime brings about reactions with these substances which render them harmless. Hartwell's experience with aluminum compounds in the soil are of special interest to workers with vegetable crops because he used in his tests a soil the behavior of which under acid and neutral conditions has been determined for a large number of vegetable crops, as well as the common farm crops. In one test he applied to a sample of this soil acid phosphate at the rate of 28 tons per acre, and later grew an excellent crop of lettuce upon the same soil, although lettuce is believed to be very sensitive to soil acidity. He had in other experiments shown that, according to the Jones acidity test, the acidity of the soil is enormously increased, though perhaps only for the time being, when large amounts of acid phosphate are applied. When the acid phosphate made possible the growth of lettuce on the acid soil, it was thought to have formed with aluminum insoluble aluminum phosphate, which is harmless.

3. The behavior of the cabbage, potato, and tomato crops on the unfertilized soil in this experiment, has been what one would expect if the ranking of vegetable crops for lime requirement, as proposed by the Rhode Island Station, is accepted. It seems safe to say that, the soil at the Rhode Island Station having been shown to contain large amounts of soluble aluminum when in apparent need of lime, any ranking of crops for lime requirement made according to their behavior on that soil, must be concerned

to a large extent with their resistance or non-resistance to the toxicity of aluminum. In our tests, the potato crop has been the least variable when grown on the check plots; the tomato crop has shown a somewhat greater effect of acidity, while the cabbage crop has been injured very noticeably. By Hartwell the potato and tomato are placed together in a class of crops that as a whole require little lime, while the cabbage has been placed in another class said to require much lime, though not the maximum amount. It seems likely, therefore, that the behavior of these crops indicates to some extent that much the same soil conditions as to acidity are found in Pennsylvania as in Rhode Island.

In conclusion, then, soil acidity, which is believed to be, under the conditions prevailing in this experiment, much the same thing as aluminum or iron toxicity, is assumed to explain the principal differences in yields of the plots in question. In several cases the presence of large amounts of organic matter, washed down from slightly higher ground, has seemed to have counteracted the effect of soil acidity in those plots, while in more elevated plots the native tendency toward acidity has prevented the accumulation of organic matter from crop residues, so that such plots become less productive year by year. It is probable, also, that the varying composition of the soil of the plots, the inequalities in the depth of the surface soil, and the differences in depth and composition of subsoils, have contributed a fair share to the yield variations. Changes in soil texture from plot to plot, dependent somewhat upon the slope of the land and partly upon the nearness of bed rock, have had some influence. Taking these several causes of variation into consideration, one seems justified in thinking that the usual method of correcting yields of treated plots lying between control plots is not applicable in this case, and that the replication treated plots is the only safe resource.

The present knowledge of the toxicity of aluminum and iron salts gives rise to some curious questions as to the interpretation of the results of fertilizer tests involving acid phosphate, since it is well known that soluble phosphates, as well as lime, combine readily with either iron or aluminum, rendering them harmless for the time being. While doing this, however, the phosphates also lose to a large extent their own usefulness as plant foods, since iron and aluminum phosphates are thought to be but slightly available to plant roots. When one gets an increase in growth following an application of acid phosphate, therefore, can he be sure that the increase has not resulted less from the action of phosphorus as a plant food and more from its effect on soil toxins of the iron and aluminum order? This brings forcibly to one's attention the need of care in fixing upon the policy to be used in applying lime in a fertilizer experiment, since lime is a much cheaper material than acid phosphate. Finally, some one will have to find out to what extent crops differ in their relation to soil acidity of the several kinds that are believed to exist, since only when this has been determined can we make any accurate recommendations as to liming particular crops on particular soils.

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The Trend of Research in Pomology

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DUCLAUX says science progresses above all by changing its point of view. A discovery of striking or dramatic interest often stimulates research, not alone in the science to which the discoverer belongs, but in other related sciences. This tendency of workers to shift their attention to fields of research that have been made popular by striking discoveries often results in exhaustive and critical study, and perhaps a rapid development of a new system of knowledge. In a subject like pomology, however, where, because of the nature of the material, new truth must be established very slowly, it would be unfortunate if the shift to new fields that have been brought strikingly to attention should be so rapid that such a field would not be exhaustively worked before the shift to another. From this point of view a brief survey of the history and present trend of research in pomology seems desirable.

Early writers seem to have based their recommendations, not so much upon results of experience as upon the fundamental nature of the tree as they understood it. At least in recommending a practice they generally tried to give a physiological explanation for it. This, of course, does not exclude the possibility that the author reached his own conclusions as a result of experience. Certainly, however, writers in France, where horticulture so early became a college subject, based their recommendations as to practice largely upon real or imagined physiological principles. And French teachers seem to have had a large influence upon the early horticultural thought of England and parts of America. Experimental study of orchard practices began much later than with many other crops. Rather large emphasis was early placed upon chemical analyses particularly as a means of estimating the fertilizer needs of the tree. The number of publications giving results of chemical analysis of leaves, twigs, and fruit as a basis for

recommendations as to fertilizer practice, is large. It is needless to say that conclusions based upon such studies were not always correct. Even with our present greatly increased physiological and biochemical knowledge, it is seldom safe to base recommendations as to practice upon such knowledge alone.

During the past fifteen years there have been appearing in print the results of a considerable number of field experiments. These have not fully satisfied the hopes of workers in the subject. That the results of different experiments should be conflicting was to be expected since soil and climatic conditions were not the same. However, one result of these field experiments probably no one had anticipated, that is the very large experimental error involved. In few, if any of the experiments, are conclusions justified where the differences are no larger than 25 per cent, perhaps with the larger number a difference of 50 per cent would hardly justify conclusions, and with some a difference of 100 per cent is not significant. In other words, with some experiments where a given treatment has seemed to double the yield, it is not at all certain that the difference in the yield of the two plots is due to the difference in treatment.

On account of these difficulties with field experiments, there is among workers now a tendency to give them little value and to attempt answering practical problems by means of physiological studies; that is, studies in the nature and response of the trees. It seems certain that such studies are very valuable, and no doubt with some cultural problems trustworthy answers may be secured in that way, without resort to field experiments. Then, we must know much more about the tree and its response to various environmental differences, before the results of field experiments, or of diverse practical experiences, can be wisely interpreted. It would probably be fortunate for the field of pomology if, for a considerable time, large attention should be given to physiological studies.

Probably the trend away from field experiments has not been encouraged more by the great uncertainty resulting from them, than by the promising field emphaized by Kraus and Kraybill. This interest in the influence of the carbohydrate-nitrogen-water relationship upon growth and fruitfulness, constitutes for pomology one of the changes in emphasis that makes for progress. It is to be hoped that this emphasis will continue until the influence of this relationship is known for every important cultural and climatic variation, and particularly every stage in the annual development of the tree.

It is probable that such work cannot be completed without more exhaustive study of the rest period of plants. Most of the study of the rest period has been concerned with that portion which comes after the leaves are off. Unless it be in the southern portion of the temperate fruit growing region, we are more concerned with the portion that comes before leaf-fall. During this period, which begins sometime after the terminal buds have formed, the trees when given favorable temperature and moisture conditions, will not generally respond with new top growth. What evidence we have indicates that root growth continues through this period. There are many problems concerning this portion of the

rest period. Thus, for each fruit we need study as to how soon after the terminal bud forms the twigs are fully in the rest period, and if that condition can be detected by any characteristic of the buds, of the wood, and whether or not the cambium is always in a resting condition when the buds will not grow. We know that in soils deficient in nitrogen, if that element is applied while the trees are in this condition it will be taken up and will cause a deeper color in the leaves without necessarily stimulating top growth. What effect does this have on the carbohydrate supply? If top growth is not stimulated, is there an increased root growth? What effect does increasing the supply of water or nitrogen, or both, during this period, have upon the maturing of the wood? Do the twigs go into this condition before the wood of the larger branches and the trunk, and if so will a large water and nitrogen supply rather early in this period tend to stimulate "water sprouts" or late cambial growth?

The effect of fruiting upon the tree should be studied, of course, as to its effect on the carbohydrate-nitrogen ratio, but also as to its influence upon the tree in other ways. Does it reduce the growth of the tree only by the amount of dry matter diverted to the fruit, or are there additional dwarfing effects due to seed formation, bending of branches, reduction of leaf surface, and perhaps other causes, and if so which of these is most important in its influence? These are only a few of the general groups of problems that seem promising for study in order that our knowledge concerning the nature and responses of fruit trees may be as complete as possible.

Yet in spite of our faith in the ultimate value of such fundamental studies in the solution of practical problems, we should not expect too much in the way of immediate results. If we could hope to have complete knowledge concerning the nature and responses of the tree we could, of course, safely derive from that a system of cultural practices. However, all of the problems mentioned above and many more are interrelated, and we cannot have a complete solution of one general problem until the related problems are solved. It is, therefore, often dangerous to base a recommendation as to a practice upon a fundamental principle, because we may not know how its working is modified by other fundamental principles not so well understood. In fact, it seems probable that the more fundamental the problem studied, the greater is the danger of misinterpretation. It seems to me, therefore, that we must not despise studies that might be classed as less fundamental. That is, studies pursued with the hope of increasing our knowledge of the responses of the tree even though the chemical or physical explanation of those responses may not be known. Certainly the total contribution from such studies has been very great. The control of insect pests and plant diseases, has resulted from field trials and from gross life history studies without the fundamental explanation of the behavior of the organisms. More fundamental research in these lines is to be encouraged, but certainly he would have been an enemy of American agriculture who might have insisted that these somewhat superficial studies that have saved our American fruit industry, and

perhaps other agricultural industries, should wait upon the slow results of more basic studies. An example of the slow or even futile results that often follow attempts to establish the ultimate nature of a process is to be found in the studies of killing by low temperature. Very useful results have followed studies as to the response to low temperature of different fruits and varities under different cultural and climatic conditions. However, results following the numerous attempts to learn the fundamental nature of winter injury have yielded so little that, from the standpoint of practice, more could have been learned by a walk through an orchard after a severe winter. We are glad that these studies have been made, and we have faith that the ultimate truth may yet be discovered and that it will be of practical value, but to have refrained from making the more superficial studies while waiting upon this ultimate discovery would have been very harmful to the industry. Further, it is not impossible that these studies, less fundamental in point of view, may yet yield most toward a final answer as to how freezing kills. It seems to me that we may be guided by experience in many fields, the wisest point of view is that any truth about the tree is worth seeking, whether the information sought concerns merely the responses to some change in environment, or is the deeper explanation of some such response.

Further, while physiological studies are certainly to be encouraged, I do not believe we are ready to drop the field experiment. There will be some results of laboratory studies that can be applied directly to practice without field study, but in most cases on account of the very complicated nature of the fruit tree, one cannot be certain as to the field application of a laboratory finding until it is tried in the field. And a careful survey of the results of the field experiments will, I think, convince any one that the contribution has been large. Thus, we have fairly conclusive proof that in the American orchard potassium and phosphorous are so seldom present in the soil in insufficient quantities for high production of fruit trees that the problem as to these elements is at least a minor one. On the other hand, while we formerly applied nitrogen with some fear that it might stimulate vegetative growth to an injurious extent and thus reduce fruitfulness, we have found that this very seldom happens and, as a matter of fact, nitrogen is the element that can most often be applied with profit. Further, we have learned that while the soil must be low in available nitrates before the apple, pear, blackberry, and probably the currant, when grown under the cultivation and cover crop system, will show response to applications of nitrogen, the peach, cherry, plum, raspberry, and gooseberry are much more likely to show a response. By field experiments we have learned, not only the injurious effect of sod on trees, but that by the use of nitrogen that injurious effect can be largely overcome. We have further learned that nearly all orchardists have been pruning young trees too severely and thus delaying the time when they should be expected to bear profitable crops and that summer pruning does not stimulate fruitfulness, but probably the reverse. We have also learned, with reasonable certainty from experiments that alternate bearing of fruit trees cannot be

prevented by thinning, and that thinning can be expected to be profitable only through the influence on the crop thinned, or through its effect on the growth of the tree. All of this is information of the greatest value, since it concerns the most essential orchard practices.

We can be certain, however, that in the future, field experiments will be of a different nature. First, the problems investigated will almost certainly be more limited in scope. We shall hardly expect reports of experiments concerning such general problems as the relative value of tillage and the sod mulch. In tillage we shall probably investigate problems as to the value of continuous tillage through the summer, let us say until September, as compared with ceasing tillage as early as July 1st, or even earlier. In fact, a study might very profitably be made as to whether or not any tillage after the spring plowing and leveling of the soil is profitable. Even more specific problems as to whether or not, when a period of several years is considered, ceasing tillage in June or earlier in order to permit the growth of a heavy cover crop, actually reduces the moisture supply in late summer. or whether the increased supply of humus where cultivation ceases early may not, by increasing the water holding capacity of the soil, increase the water supply more than late cultivation would. We should also learn by field experiments whether, when for unavoidable reasons the spring plowing has been delayed until after the fruit has set, or failed to set, and the season's growth has nearly been made, it is better to plow the orchard or wait until the following spring. Similarly, in the study of pruning, the relative value of specific types of pruning will probably be studied rather than such general problems as the relative value of much or little pruning, or summer and dormant pruning, though this last question can hardly be considered settled. Of even greater importance and requiring more detailed study, is the problem as to the age of each kind and variety of fruit when, for a given climate, renewal pruning may be profitable.

And in planning the experiment, more consideration must be given to the nature of the tree rather than merely to the formal cultural operation. The summer pruning experiment by Drinkard is a good example. Trees were pruned in the spring to be compared with trees pruned on June 23, when length growth had practically ceased. The trees were five years of age and we can be certain that each succeeding year the new twigs constituted a smaller proportion of the whole top. Cutting away all of the 1912 twigs would then be relatively more severe pruning than cutting away all of the 1913 twigs. In other words, his spring pruning was, in proportion to the size of the tree, more severe than his summer pruning. His trees pruned in the summer of 1913 should have been compared with trees pruned in the dormant season of 1913-14. Fortunately some trees were pruned in the fall of 1913 and it is these that should be compared with the summer pruned trees. When that is done, the results are very different from those generally considered to have been shown by this experiment.

Experiments in the field will also be done with very much more care than was thought necessary at the time the earlier field ex-

periments were planned. These earlier field experiments have given us valuable results only because in the problems studied the differences were very large. As we narrow the problems down to questions involving more minute details of orchard practices, we must so refine our experimental methods that smaller differences will be significant. Several methods of reducing experimental error suggest themselves. First, there should be several plots receiving each treatment, these plots being distributed evenly over the experimental area. Thus, Batchelor and Reed found that the probable error on 16 trees was but little more than half as great when each treatment was given to 4 plots of 4 trees each (these plots being distributed evenly over the experimental area) instead of to one plot of 16 trees. These authors found that there is little reduction in the experimental error by having more than 8 trees in the plot, the better plan being to have many small plots receiving each treatment. Second, where trees of bearing age can be used in an experiment, perhaps the most important improvement in our experimental method would be to give all of the experimental area uniform treatment for a period of two to four years after which the different plots would receive the treatments called for in the plan of the experiment. The plots could then be so arranged that the average yield for each plot during this preliminary period would be nearly the same, or if the experiment should be one requiring symetrical plots the average yield of each tree during this period could be used in estimating the probable yield if the treatment had not been varied and, therefore, in estimating the increase or decrease in yield due to the treatment. It would seem wise for departments to grow, for future experiments, orchards under uniform treatment for all of the trees, keeping complete records from the start. Not only would the experimental error thus be greatly reduced, but the experiment ultimately decided upon could be planned after much reflection and in the light of all of the new results published after the planting of the orchard and before the beginning of the experimental treatment. Third, where the problem concerns young trees the error due to variations in the soil could be greatly reduced by planting the trees closely so that the experimental plot could be smaller and the possibility of introducing large soil variations, therefore, smaller. By this method too, the young trees could be dug up or cut off and weighed. It is not necessary to emphasize the fact that unless the number of trees to the plot is large, the weight of a tree is a much more accurate measurement of growth during a period of years than either trunk girth or twig measurements, this last being nearly worthless unless the form and growth of the top of every tree is kept the same. With such young trees, and probably with all trees in soil management experiments, more care should be taken to have the pruning of the trees alike. Since the mere rubbing away of buds from young trees may reduce growth, it follows that the number of initial branches left should be the same for each tree.

Some are of the opinion that field experiments may be largely replaced by pot experiments where the trees can be grown under controlled conditions. It is difficult to secure conditions in pots that give a normal tree growth. In fact, it is doubtful if the

uniformity of behavior of trees in pots with a given treatment, is equal to that under field conditions. In a college where there was an effort to increase the working program in the courses without reducing the number of credit hours to the available subject matter, the students complained that the courses were rendered, not more difficult, but only more inconvenient. We might say of trees in pots that generally the growth is not controlled, but only handicapped. I do not wish to be understood as considering pot experiments with trees as of no value. I believe that good use can be made of potted trees, particularly for studying the response to abnormal conditions. I feel very certain, however, that they cannot replace field experiments, and that any results secured from them must be applied to practical conditions with great caution, for their responses may be very different from that in the field. Thus, if the trees should be placed in a growing temperature while still partially in the rest period, pruning and possibly even some soil treatments might tend to break the rest period. The response then would not be the same as if the trees had completely finished the rest period while at a temperature too low for growth.

It is needless to say that field experiments that are to have more than local significance must be in reality physiological studies. That is, they must give results in terms of responses particular to the tree rather than merely comparison of practices. Thus, in fertilizer experiments it would seem that the response of fruit trees should be compared with that of some standard crop like corn growing in the same soil. Further, if the response of all of the different fruits to the same treatment in the same soil could be established, the information would be of much greater value than when each fruit is studied separately in a different soil. While we have some knowledge as to the relative response of the different fruits gained largely by separate experiments in different soils, or by experiments with young trees only, the value of more precise information for bearing trees is evident.

It would be well if, in so far as it is possible, there should be associated with field experiments special physiological or chemical studies pursued with the hope of explaining fundamentally the responses shown in the field. These may not always be possible and it seems to me that if the responses that can be noted in the field are established through careful records by one man, the explanation of these responses may be studied by someone else working separately even with different trees so treated as to show the same responses. Of course, some will hold that such experiments should always be conducted by pomologists, chemists and perhaps physiologists cooperating. To one whose knowledge of human nature, and especially scientist nature, has not been lost in his enthusiasm for organization, this does not seem so certain. Such cooperating sometimes works well but while it has been advocated since the time of Bacon, certainly most of what we know has been learned by men working separately. A man's problem, particularly if it is one based upon penetrating study, may be so peculiar to himself that it is difficult to cooperate with some one else. It might be better for the chemist to have his own trees and conduct his work separately. And the pomologist himself must be

trained to do much of the work that he has generally called upon others to do. The man who bemoans the lack of cooperation in research, (and we shall probably hear him at the millennium) overlooks a cooperative system that is probably unexcelled. I refer, of course, to the methods of scholars in publication and citation of experiences. Every man who with scientific care puts his experiences on record is, of course, cooperating with anyone who needs such results in developing his own work. Such cooperation does not depend upon mutual regard and does not dwarf initiative. Each man brings his contribution in his own way, and whether this be as modest nuggets, or as gilding over the surface of a balloon, workers will readily find it and give it its true place in the system.

The subject of pomology is at a stage where reviews of the evidence now available are needed. Of much service in the development of effective research will be the publication of books in which an attempt is made to evaluate all experimental evidence that contributes to the development of an orderly system of knowledge concerning the responses of all of the various fruits and fruit plants. On account of the long life and complicated responses of trees. however, such critical treatment would be of less value if not done in the light, not merely of science, but also of intimate association with trees in which subtle responses to various environmental conditions are considered. Many observations that can be put into words with difficulty, if at all, are of help in forming dependable judgments as to what will be the response to a given treatment under different environments. It seems to me that lack of this intimate contact is often shown in attempts of other scientists to interpret work they have occasionally done with trees. Such impressions from intimate contact with trees, without scientific knowledge of their responses including the more fundamental explanation of those responses, is of little use in evaluating a new practice, but all three must be used together. While either used alone may be dangerous, the danger is probably greatest when the sole basis for a conclusion is some chemical or physiological discovery so far removed from the immediate response to actual practice that complicating phenomena might be overlooked.

It is probable that more often than otherwise when a discovery is made that explains in a fundamental way some response of the tree we shall look. not forward to its application, but backward to find it already in practice, placed there by the results of experience; of field experiments; and of studies of the more superficial responses that the more fundamental study explains. The pursuit of the fundamental study is to be encouraged, however, because of the possibility that it may yield information leading to better practice; because of the certainty with which it establishes previous conclusions; because of its probable contribution to the solution of other problems; and because the development of scientific agriculture would certainly be delayed by ignoring the inspiring tradition of science that truth for its own sake is the greatest reward of research.

Problems in Teaching Freshmen Pomology

By C. F. BRADFORD, *University of Missouri, Columbia, Mo.*

THE recent action of Yale University in segregating administratively the freshman class from the remainder of the undergraduate body, giving it a distinct faculty headed by a dean of freshmen, recognizes and attempts to meet certain problems which must have been apparent to any careful observer of the period of transition from preparatory school to university life. These problems are numerous and difficult in any institution; in a technical undergraduate school they are, in some respects certainly, still more so, for not only must the freshman adjust himself to new environment, new methods and new ideals, but, theoretically at least, he must lay the foundations of a considerable fund of technical knowledge.

He comes to the university, trained, if he is trained at all, along certain well defined, but rather narrow lines. His every move has been inspected and supervised and checked; his academic neck has been inspected every day to see if it has been properly washed; he has been catechized daily as to the state of his academic soul and at the end of the day he has been tucked safely away in academic blankets. His idea of study is to memorize what he is told to memorize, to translate to a certain line and stop. At the university he finds that nobody is particularly concerned with his ears or his blankets or his soul, that the day of academic reckoning is far off—several weeks at least—and that people have a curious way of passing out information without pausing to make sure of his understanding it. It is a wonder that he survives the freshman year.

The task, then, of the teacher of freshmen, is not only to impart information, but also to help in the adjustment to this new environment. He must show the students how to weigh and arrange evidence, how to take notes, to think, to work consistently, to be punctual without continual nagging, in short, to govern himself. This is the task that is delegated usually to the inexperienced men of the department, not because they want it, not because they are peculiarly fitted for it, but because they cannot pass it on to someone else. Often it is treated as a neessary evil, something to be endured in order to secure opportunity for research, or to be tolerated until the teacher graduates to teaching advanced students. How many teachers are hired for or assigned to this course because of any special aptitude for it? Rather fewer, probably, than are assigned to it because they are not yet fitted to handle the other courses.

Numerous as the questions arising from teaching freshmen are, those with peculiar application to freshmen pomology may perhaps be grouped under two headings, to wit: what shall be taught and how it can be taught best.

In deciding what shall be taught several points must be settled. In most institutions it seems fairly well agreed that the

freshman pomology course is designed primarily for the student who will take no further courses in the subject. To this extent we have progressed since the days when all students were required to take plant propagation even though no other horticulture was prescribed, when flute budding was taught to every student and codling moth control to the major student. It still appears difficult, however, to consider this freshman course other than as an introduction to the subject and there is a marked tendency to hold up the "good things" for later courses. There is a disposition to discuss some topics thoroughly and with finality, to get them out of the way, to clear the track, so to speak, for the later courses. Perhaps, for example, we instruct the student in the minutest detail of locating and establishing an orchard and let his prescribed instruction end here, telling him that further marvels will be exhibited at the next performance. Though this may be good practice in the circus lot, in the university it results in a large proportion of students graduating with no conception of what to do with the old orchard at home.

Many of us ponderously discuss whether we should teach facts or principles. Why distinguish? Is not our real problem the decision as to what is likely to be useful to the greatest number? Is it so important that the student remember formulae and spray calendars as it is that he know where to find one and how to use it? Accomplishing this last is itself no mean achievement. And still we can leave something for subsequent courses. In the course which the writer teaches an interesting hour is spent on the pollination question, but so far no complaint has come from those teaching the advanced courses that the students know all about pollination when they reach these courses. We tell our freshmen as much about winter injury as any well informed farmer should know; nevertheless, those who teach the advanced work have enough fireworks left to entertain the major student for a three or four weeks period. In short, if all that is worth teaching can be taught in the freshman course we may as well abolish the other courses. We can't. However, we should feel free to discuss any phase of pomology likely to be useful to the student who is going into other lines, unhampered by any fear of stealing the thunder of the subsequent courses. If the use of such subject matter in the beginning course robs the later courses of their "punch," the question may legitimately be raised, "Do they now possess enough punch to be worthy of three or five or ten credit hours of the upper classman's time."

In laying out the subject matter, the general scheme of what Doctor Charters calls the "job analysis" is useful. The course should be an epitome of what any farmer should know about pomology. Extension men know the questions the farmer is asking. The department correspondence is sometimes revealing. The experience of the instructor should be suggestive. This alone is not enough; in the framing of the outline, attention should be given not alone to the questions the farmer has asked and is asking, but sometimes a forecast can be made of some questions he is going to ask and occasionally attention should be given to questions he ought to ask.

Collecting this material and arranging it into some sort of log-

ical and useful order is in itself no mean task. The instructor will not be embarrassed by lack of material. Rather he confronts a greater problem in trying to teach this irreducible minimum of information.

He is not in the position of the teacher of some cultural subjects where a twenty per cent absorption of knowledge is ample, where merely living in the college atmosphere is education enough. He cannot take the attitude of the man who is teaching upperclassmen. He must do more than say, "Here it is! Come and get it. And the devil take the hindmost." He cannot run out his tank and call it a day; he must cover all surfaces, use spreaders if necessary and make his stuff stick.

Perhaps the best help to the instructor is the interest of the student. Most important in securing this is the interest and enthusiasm of the instructor himself, his conviction—temporary at least—that what he is saying is of tremendous importance. But this interest will be more effective if it attaches not alone to his manner but to the subject matter itself, beginning perhaps with arrangement.

It seems decidely open to question whether our traditional arrangement of subject matter is the happiest possible. True, in the actual establishment of an orchard, the selection of a location and a site is one of the first steps, but is this the point of departure in the quest of knowledge about orcharding? Is it not rather one of the culminating points? Does not a considerable amount of knowledge and experience go into judicious selection of a site? We tell the student to avoid sites subject to frost and we either take time out at once to tell him why, or we wait several weeks before we tell him the real importance of avoiding frost. We spend good time in discussing soils at this point, though after he has studied cultivation and nutrition five minutes would suffice. Will he understand location and sites for peaches or anything else better before or after he has studied about those fruits? Will he get more out of a talk on selection of nursery stock before or after he knows the problems of the bearing orchard? In short, are we not in some respects putting the cart before the horse and wasting time in order to do it?

In the presentation of each topic there are potentialities. A talk on pollination can begin with a discussion of the anatomy of the blossom. It should not, however. It will be more interesting if introduced by outlining a mysterious succession of crop failures such as those in the cherry orchards at The Dalles, Oregon, where thousands of orchard heaters were used vainly to remedy the situation, then leading through the observation of sporadic setting in the neighborhood of seedling trees to the final unravelling with a fade-out of a successful happy fruit industry. Though no student in the class intends to grow pineapples in Hawaii they will all be interested in the paradoxes encountered in some of the soils there and they will be helped to a better understanding of the problems of nutrition. Tell them that Iceland is warmer in the winter than the peach belt of Michigan and they will understand climatic requirements better.

Another help in fixing information and sustaining interest

is in letting the student know how he stands. He is always interested in his grades. Begin or end the lecture with a five minute written quiz in some phase of the previous lecture and that point is hammered home and the student has something in the immediate future to which he looks forward—the return of the last paper and the answering of the next. And if these questions are thought out carefully so as to involve a practical application of the information they not only sound his knowledge, but they point to him the application. For example: the instructor can ask, "What is the special value of the pink spray and of the calyx spray?" If the student is a good parrot he will wearily say back what the instructor has said to him. Let the instructor ask him what he would do in case his spray rig broke down while he was applying the pink spray and before he got it running the trees were in full bloom. The instructor can still find out what the student knows and the student has come in contact with practical application of his knowledge.

And as the Ides of March draw nigh and the final examination approaches, let the instructor study about the examination as the student studies for it. The composing of these questions should involve much thought. The writer has in some measure solved two problems by permitting students to use their lecture notes and their text-books and giving them questions involving application of their knowledge and so many of them that the student who did not know the subject tolerably well would have extreme difficulty in finding the answers in the allotted time. A carefully prepared examination will instruct as well as measure the student.

With the blue books in, instruction of the instructor should begin. He can, to be sure, hand them over to an assistant for correction and later, looking over the grades, he can complain that this year's class is unusally boneheaded. That is one way and it is easy and comfortable to the complacent. On the other hand, he can grade the books and in doing so grade his own performance.

A recent experience of the writer was illuminating to him. After the books were graded the marks were tabulated, question by question. The array for some of these questions is shown in the table. Question VI, bearing on pollination, was the most complicated and probably the most difficult; Question VIII involving merely a differentiation between intercrops and covercrops was presumably the easiest. For some reason the class averaged better on the more difficult question. Since the failures were apparently not due to misunderstanding the questions the

Question	Grades 0	1	2	3	4	5	6	7	8	9	10	Average
VI.	5	2	1	5	14	5	2	27	10	2	12	60.3
VII.	5	2	1	8	19	13	6	7	11	6	8	55.3
VIII.	10	1	8	5	14	11	2	8	4	22	1	52.4
X.	31	1	..	..	..	1	..	..	..	3	49	51.1

cause of the difference must lie in the presentation of the two subjects in the lecture room. With a complicated subject the approach has been worked out carefully to promote interest and clearness; the other subject being in a measure less difficult was approached in an off-hand, colorless and rather uninteresting manner.

Question VII, on spraying, was not answered satisfactorily for a somewhat different reason. Since previous experience had shown the necessity of drill in distinction between contact insecticides, stomach poisons and fungicides, this was given in the daily written work. Out of an almost infinite number of possible mistakes the actual distribution was as follows:

Useless materials indicated	14
Confusion insecticide and fungicide	8
Stomach poison for aphis	2
Contact poison for chewing insects	0
Omission of follow up sprays	101
Unnecessary materials included	116

The points on which drill was given were answered satisfactorily, but next time the drill will be more inclusive.

For a time the array for Question X was distinctly puzzling. This Question was of such a nature that the answer was right or wrong, though a few cases of lucky or unlucky phraseology drew intermediate grades. This very question had been asked on a daily quiz and afterward explained in class. After much cogitation it was recalled that while the post-mortem explanation was going on, the weather being warm and the doors open, a Missouri hound had wandered amiably in one door, crossed the hall in front of the rostrum, gazed approvingly at the class and left by the other door. That dog must have cost nearly thirty students ten points on their final examination grade, but he furnished the teacher with a good excuse. Unfortunately there is no hound to take the blame for Question VIII; in this the failure of the class to achieve better results devolves on the instructor, not on his students.

Cost and Production of Tomatoes for Canning in Kentucky

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IT will be remembered that in the early part of 1920 the tobacco markets of the country were very low owing to cancelled Italian contracts. Kentucky suffered severely since she was probably at that time the biggest producer of black tobacco in this country. This condition naturally lead some of the farmers to cast about for substitute crops. As a result tomato "canning" areas,

* The information given in this paper was obtained while the writer was a member of the staff of the Kentucky Experiment Station and is available through the kindness of the Horticultural Department of that Station.

roughly estimated at 4000 acres, were contracted for the first time in several counties in the southwestern part of the state, and limited areas previously devoted to the crop were greatly expanded.

The new areas were around Utica and Livia in Daviess County, Calhoun and Rumsey in McLean County, and Hartford in Ohio County. The increased areas embraced the Corydon, Reed, Robards and Henderson sections of Henderson County together with tracts around Cayce, Fulton and Hickman in Fulton County. This evidenced interest of the growers as well as the lack of applicable cost data on a crop which promised to become a partial substitute for tobacco, seemed to make an immediate survey imperative.

There was, at the time this survey was completed, considerable controversy between the growers and canners of the crop in some of the established tomato growing sections as to a price which the growers of a section could justly demand and the contracting canners profitably give. Consideration was also given to the possibility that this "correct" price (from both aspects) probably varied in the different sections since tomatoes are grown for canning purposes under such a variety of conditions. With this possibility in mind the survey was planned to embrace the following:

1—To determine as accurately as was possible by the survey method the prodution cost of the crop that both the grower and canner might have reliable data on which to base a price and, 2—To procure, from the horticultural standpoint, information concerning the conditions prevailing and the cultural methods practiced in the production of the crop so that reliable recommendations could be given to the growers.

The general conditions, in the considered areas, which would affect the crop, were comparatively similar. The representative farms of the surveyed sections were not taken at random, but were selected with the view of including as far as practicable the many diversified conditions under which the crop was produced. The areas chosen ranged in size from 1 to 15 acres. The crops considered were produced on bottom, second bottom and upland soils which varied in drainage, fertility and preparation for the crop. Information was gathered which covered production from areas planted with home grown, commercially grown, "topped," transplanted, "stocky," and spindling plants. Crops were considered from areas of complete stand, from those having missing plants, from sprayed and unsprayed areas as well as from areas necessitating both short and long hauls to market (¼ to 9 miles). The experience of the growers was also considered an important factor in the successful production of the crop. Combinations of these factors occurred in the majority of cases.

The record forms, furnished by the Department of Farm Management of the Kentucky Experiment Station, were distributed to the growers and instructions given as to their use by a representative of the Station on his frequent calls during the season. At the same time such general information as the experience of the growers with the crop, soil conditions, cultural methods employed, and other miscellaneous data which would have a bearing on the problem were secured.

The rates and standards upon which the computations were based were obtained as follows:—

1.—Man and horse labor charges for general farm work were obtained from the averaged data of a large number of growers. Man labor was 24.6 cents per hour and horse labor was 16.6 cents per hour.

2.—Machinery charge was obtained from the Department of Farm Management of the Kentucky Experiment Station.* A cost of 7 cents per hour was charged.

3.—The crate and basket weights were obtained from data given both by the growers and canners as well as first hand observation of the representative. A filled basket weighed 33.5 pounds (59.4 baskets to the ton load) and a filled crate weighed 57.2 pounds (35 crates to the ton load). Baskets were used as containers in Henderson county and crates in the other sections.

4.—The picking charges were computed from the wage in the several sections. They were 5 cents per basket and 10 cents per crate.

5.—Hauling charges were figured on the assumption that a trip (to market and return) required the services of a man, two horses and a wagon. and that a trip was necessary for every ton marketed.

6.—Land rental in each case was obtained from the grower who based his estimation on the assumption that he was renting.

The computation of the accounts is considered under three heads, viz., labor cost to time of harvest, harvest and delivery, and general expenses. This latter included all miscellaneous expenditures such as land rental, seeds, fertilizers, spray materials, etc.

Of the 112 accounts placed only those of 47 farms embracing 167.63 acres of tomatoes were used. From this planted area 651.16 tons were marketed showing an average yield per acre of 3.88 tons. The costs as determined by the survey are:—

Cost of Labor to Time of Harvest

8, 852.0 man work hours at 24.6 cents per hour	$2,177.59
7,404.5 horse work hours at 16.6 cents per hour	1,229.15
4,468.0 machine work hours at 7.0 cents per hour	312.75

Average Ton and Acre Labor Cost to Time of Harvest

		Per Acre	Per Ton
Man Labor	Hours	52.806	13.594
	Cost	$12.990	$3.344
Horse Labor	Hours	44.171	11.371
	Cost	$ 7.332	$1.888
Machinery	Hours	26.653	6.861
	Cost	$ 1.866	$ .480
Total		$22.188	$5.712

* This department has completed a tobacco cost survey of the principal black tobacco sections the season preceding which furnished applicable machine labor cost since the same machinery was used in the production of both crops.

Cost of Harvest and Delivery

Picking	651.16 Tons	$2,181.10
Hauling	651.16 Tons	$1,215.09
Total		$3,396.19

The average hauling distance on the 47 farms considered was 2.9 miles requiring an average trip time of 2.5 hours.

Average Ton and Acre Cost of Harvest and Delivery

	Picking	Hauling
Per Acre	$13.011	$7.248
Per Ton	$ 3.349	$1.866
Total	$20.260	$5.215

General Expenses

Land rental	$2,478.62
Seeds, plants, etc.	480.40
Fertilizers	231.10
Spray materials	17.33
Total	$3,207.45

Average Ton and Acre costs for general expenses were $19.134 and $4.925 respectively.

Total cost of production	$10,323.14
Average cost per acre	61.58
Average cost per ton	15.85

So that there would be less chance of disagreement should the growers and canners ever use the results of this survey as a basis for establishing price, estimations and causes were obtained from the grower of the approximate amount of his crop which he was unable to market. From this estimate the production costs were computed assuming that the grower had been able to harvest his entire crop. The losses were classified as those resulting from "field rots," lack of market, and the crop left in the field at the close of the season. It was found that the average crop loss of the 43 farms considered embracing 153.88 acres of the crop was 30.58 per cent.* Using these data the total yield was estimated to be 868.820 or 5.64 tons per acre. The estimated production costs are:—

Actual labor cost*	$3,413.478	
Actual general expenses*	2,883.350	
Estimated harvest and delivery cost	4,263.888	
Total estimated cost of production		$10,560.716
Estimated average acre cost		68.630
Estimated average ton cost		12.155

* The labor and general expense items remain the same for the estimated crop computations.

From general observations taken during the survey and analyses of the accounts together with information concerning them it is suggested that the successful production of the crop would be more assured if the following with explanatory examples were observed:—

1.—That relatively fertile, well drained and prepared land be used, as—

Farm		Yield per Acre in tons	Labor costs per acre
21	Good stand of good plants on a strong well drained and well prepared river bottom soil	3.61	$13.53
38	Good stand of good plants on a thin poorly prepared second bottom land .	2.49	18.31

The former produced 1.12 tons more at a cost of $4.77 less per acre.

2.—That the plants be "stocky" and the "stand" complete over the entire planted area as—

Farm		Yield per Acre in tons	Labor cost per acre
8	Good stand of good plants on a strong river bottom soil	6.699	$21.89
24	Poor stand of poor plants on a strong river bottom soil	1.859	$25.71

With all other conditions apparently similar the former showed an increase of 5.14 tons per acre with only a difference of $3.82 in labor cost per acre.

3.—That the recommended cultural methods be practiced as —

Farm		Yield per Acre in tons	Labor cost per acre
4	Planted in transplanted stock and sprayed throughout season	7.941	$22.86
21	Usual cultural practice. All other general conditions on both farms relatively similar	3.617	$13.03

An increase of 4.323 tons per acre for an added labor cost of $9.83 per acre is shown on a 76 per cent increase in cost for a 200 per cent increase in production.

4.—That as large an area be devoted to the crop as is consistant with the labor supply as—

Farm	Number of Acres	Yield per Acre in Tons	Labor cost per acre
3	1.13	2.228	$41.40
7	12.00	2.190	$28.30

General conditions were relatively similar on these two farms. With a difference of only .138 tons per acre in yield, the difference in labor cost was $13.10 in favor of the larger area.

5.—That the crop be grown as near the market as possible as—

Farm	Total Picking Cost	Trip	Miles to Market	Total Hauling Cost
23	$14.90	3.0 hours	3	$ 8.28
33	$14.55	5.5 hours	9	$17.37

Here there is a difference of 35 cents in picking cost while the difference in hauling cost is $9.08 in favor of the shorter haul. Considered individually, in the first case the hauling cost was 36 per cent of the delivery charge while it was 54 per cent or over half in the latter case.

It is to be understood that the information contained in this paper is only *very closely* approximate; however, it is readily applicable to the sections considered.

Rootstock Studies in Europe

By W. L. Howard, *Deciduous Fruit Station, Mountain View, Calif.*

THIS paper is written in Grenoble, Department of Isere, in Southeastern France. I have already spent four months in my study of rootstocks in France, Spain and Italy, but it will require several months more to finish the task I have outlined, so any report made now must necessarily be preliminary and incomplete. However, it may be of interest to sketch briefly some of the things pertaining to the fruit industry I have observed while pursuing my rootstock studies.

As a matter of necessity I first took up the investigation of the origin of our cherry stocks. When I landed in France the second of July the wild Mahaleb cherries were already beginning to ripen. The normal ripening period for the Mahaleb is from July 1 to 15, but this year on account of the terrible drought prevailing all over Europe, they were almost two weeks early. According to Monsieur A. Farmand, of Angers, France, perhaps the largest collector of fruit tree seeds in Europe, there are about 2,500,000 Mahaleb seedling stocks used annually to about 200,000 Mazzard. "At least," he says, "this is they way my orders run."

Mahaleb seed is chiefly collected from the Rhone river valley in the vicinity of Lyons, France. Here I saw the last of the crop being harvested around the villages of Genas and Pusignon, each about fifteen or twenty miles from Lyons, but in different directions. The cherries occur in the hedges which are used in place of fences for dividing the fields. The broad valley is level and the land is chiefly devoted to grain growing, wheat predominating. The fields are often very small, many being only two to four acres in size, but some are as large as ten to twenty acres. The hedges

are, therefore, very numerous. The universal hedge plant here, as elswhere in France, is the thorn (*Crataequs oxyacantha*), but Mahaleb trees are intermixed and occassionally the cherry occurs in pure stand, but not often. The trees are eight to twelve feet high and are kept this height by what they call a pruning process, which consists of cutting them back to the ground or lopping off the tops every six or seven years. Some of the best trees I saw, about ten feet high, were said to be fifty years old.

No one could tell me where the cherries had come from, but nearly four months later I found old trees growing wild in the Alps adjacent to the valley of the Isere, at an altitude of about 3,000 feet and successfully competing with oaks, beech, ironwood and many other woody forms. In the wild the Mahaleb is classed as a shrub by French botanists although the trees seen were four to five inches in diameter and fifteen to twenty feet high. In open places they occur in clumps and in general outline very much resemble the native American plums.

In the low Alps I have seen numerous Mahaleb trees bordering gulches and sidehill roads where the soil had washed away so as to expose the root system. In practically every case there was a pronounced taproot running straight down like an oak. They seemed to thrive especially well on dry, gravelly and very steep hillsides where moisture was scarce. However, they appear to thrive equally well in the deep, and often moist soils of the Rhone river valley. As regards soils the Mahaleb evidently has a wide range of adaption.

The Mahaleb cherries are harvested by drawing the branches over with a hook held in one hand and beating the fruits off with a stick held in the other hand, the fruit drops into a container about three feet square made of burlap stretched over a light wooden frame, and attached to the workman's shoulders by means of straps.

After a winnowing process for the removal of leaves, twigs and snails, the clean fruit is dumped into barrels and half barrels and covered with water. Here it soaks and ferments for four or five days, being frequently stirred to admit air. When the flesh is well rotted the water is drained off and the fruit spread out in tubs to be tramped over by the men and women wearing wooden soled shoes surfaced with hobnails. A little rubbing with the hands completes the process of tearing the flesh and skins from the seeds. The seeds are then recovered by adding water and skimming off the mass that rises to the top. The good seeds sink while the defective ones float with the skins and pulp. A sieve may be used in the final cleansing process.

When clean the cherry seeds are spread out to dry on the floors of attic rooms in the peasants' cottages. After becoming thoroughly dry they are shipped to the big collectors like Monsieur Fermand who always expects to begin exporting to the United States early in August.

The exporters go into the cherry sections each year early in the season and make contracts with local collectors at so much per kilo for gathering the seed. This year (1921) cherry gather-

ing time came during the wheat harvest and this labor competition caused wages to be high, but this burden fell chiefly upon the local contractor. This summer cherry harvesters demanded and received from \$4.00 to \$5.00 per day when formerly they were paid \$1.25. Incidently the Mahaleb seed crop is short, I might say very short this year. However, the exporter is receiving only about thirty cents per pound f. o. b. French shipping points. The cost to the small nurseryman in California will probably be twice or three times this amount.

There appeared to be great uniformity among the wild Mahaleb trees. No noticeable variations as to size of trees, color or size of leaves or other growth characteristics were observed. There were differences as to quantity of fruit produced by certain trees, but this was clearly traceable to the superior growing conditions to which the high yielding trees were subjected.

MAZZARD CHERRIES

Although eighty times as many Mahaleb as Mazzard stocks are used annually in the United States, the latter are nevertheless, exceedingly important as fully ninety per cent of the sweet cherries are grown on Mazzard roots. The Mazzard cherry, *Prunus avium* or, *P. Cerasus var. avium*, is found chiefly in Normandy in the Department of Calvados very near the English Channel. I visited the section near Aunay—St. Georges, thirty miles southwest of the city of Caen. This is the apple country.

I found some of the country roads bordered with the cherry trees which attain a height of thirty-five to forty feet, and a diameter of ten to twelve inches. They almost never occurred in pure stand, but were mixed with various native trees, some of which were much taller than the cherries. Among these companion trees were*Fraxinus excelsa, Quercus robur, Fagus sylvatica, Betula alba, Ulmus campestris, U. montana, crataegus oxyacantha, Acer campestre, Populus bolleana* and *Salix sp.* For the most part these were trees that love a cool, deep, moist soil.

Mazzard cherries ripen normally about July 15. The fruit is harvested by use of long extension ladders, or by climbing the trees. These methods keep the branches badly mutilated and broken. The process of recovering the seeds is much the same as described for the Mahaleb.

The supply of wild Mazzard trees is wholly inadequate for filling the normal demand for the seeds. As a matter of fact fewer and fewer true Mazzard seeds are used year by year, the bulk of the supply being secured from confectioners and others who use cultivated cherries in ways so the seeds can be recovered. To use the words of a big collector: "Only relatively few real Mazzard seeds are collected, the bulk of the seed going into the trade being from cultivated varieties, or seedlings. These are apt to be a mixture of sweet and sour cherries."

In California, where approximately ninety-five per cent of the cherry stocks used are Mazzards, there is much discussion as to whether that is the best root to use. There certainly is great lack of uniformity in the way trees on that stock behave and many

have thought the trouble due to the rootstock. Some have strenuously advocated the use of Mahaleb for sweet cherries as well as for sour, And now there seems to be evidence accumulating that cultivated sour cherry seedlings are an excellent stock for the sweet varieties. Since most of the "Mazzard" seeds now being used are not Mazzard, but a mixture of sweet and sour cherry seed, it is quite possible that this may account for the differences in the behavior of the trees propagated upon them. This is a point I hope to be able to investigate further.

MYROBALAN PLUMS

The Myrobalan or cherry plum used so generally as a plum and prune stock in the United States, is extensively grown in fruit gardens in Northeastern Italy. The trees do not occur in Italy in a wild form so far as I could learn, but are planted for their fruit which is used to make a cheap grade of wine. In the region near Padua, about twenty miles from Venice every small farmer has five to ten trees growing among his vines and other tree fruits. There was an extensive planting of Myrobalan several years ago at a time when the vines were threatened with destruction from the ravages of phylloxera and it was thought necessary to provide a substitute fruit for wine making. The Myobalan trees, however, have proved to be profitable as collectors eagerly buy up all the seed that can be produced.

The principle collector of Myrobalan seed is the big nursery firm of Fratelli Sgaravatti of Saonari. The post office address of the Sgaravatti Brothers is Saonari but their shipping point is Padua, seven miles away. This firm is unique in that it consists of four brothers and five cousins, all young men, and each man being in charge of some special department of their work. The father of the four brothers (and uncle of the five cousins) is the executive head of the firm. They showed me a file of their annual catalogues running back 125 years. This nursery also collects apple and pear seeds from Austria. Their chief market for fruit tree seeds is the French exporters although they do considerable export business themselves. They assured me they would be glad to fill all orders for seeds or seedlings direct from America, no matter how small they might be. I mention this fact because it is an opportunity for experiment station men and teachers of horticulture to secure fresh seeds in small quantities. Inquiries should be sent to the firm as early as August if possible.

Myrobalan plums ripen normally from July 15 to August 1. The ripe fruit falls to the ground and is collected and the seeds recovered much the same as described for cherries. Through the kindness of Mr. Erinus Sgaravatti who took much interest in my studies, I was able to find seven distinct types of fruit. These differences were chiefly in color of skin and flesh and in time of ripening. No one of course knows which of these types is best for stock purposes, but I secured seeds of each of them which will be tested out as a part of the root-stock project we have under way at the Deciduous Fruit Experiment Station of the University of

California. Herbarium specimens of all the different types were collected for comparison with herbaria over here and at home.

APPLE SEEDS

The so-called French crab apple seeds are collected from the orchards of northwestern France, chiefly in the departments included in the old province of Normandy. Some also come from the old province of Brittany, but the modern Department of Calvados might be considered as one of the most important centers of the apple seed industry. So far as I could learn practically all the apples in northern France are seedlings, the few exceptions being the carefully tended trees grown in the small fruit gardens. These have to be grafted so they may be grown as dwarfs or in espalier or cordon style. The orchards always consist of standard trees and all are seedlings.

The apple orchards are generally small—from one to four or five acres, although I have seen a few so large as ten to twenty acres or even larger but these larger places are rare. The orchards are never cultivated except as it may be necessary to plow and cultivate for the benefit of intercrops. The principal orchard intercrops are wheat, oats, rye, barley and grasses. The trees appear to be healthy, so far as diseases and insects affecting their vitality are concerned, but they make very little annual growth and this year they seemed to be very weak from lack of moisture. The excessive drought prevailing all over continental Europe this year, hit the apple trees especially hard and the fruit was very small. Fortunately the size of the apples cut very little figure as everything is converted into cider.

There are a great many different kinds of apples,—perhaps I should say types, for they are not known by variety names. There are considerable differences in habit or manner of growth of the trees among the various types. There are likewise differences in quantity and quality of fruit produced. And, finally, the blooming period varies among the different types as much as three or four weeks and possibly longer. As I passed through the apple country on the train on the second of July just after landing in France, there were a few scattering blooms left and one man has reported seeing some trees covered with blossoms on June 15. I shall look into this matter more closely next spring although I may have to leave the country before the latest trees come into bloom.

As before stated, all the apples are converted into cider which is allowed to "harden" to the proper degree when it is clarified and kept in casks and bottles and serves as the universal drink for most of the people of the region, and is also sent to many other parts of the country. This cider is very cheap, selling even many months after the vintage season for ten cents a quart and now in the month of November just after being made at four and five cents a quart. This is less than half the price of the native wine of the country and, for the benefit of discriminating Americans, I may say it has more "kick" to it than the wine. Nearly every Frenchman has either wine or cider with his midday and evening meals. In addition, every farm workman carries a supply of one

of these liquids with him to the fields for use between meals instead of water. But even so they are a temperate people so far as drunkenness is concerned. Most farmers make their own home supply of wine or cider and sell what they do not need. I have visited many, many farm homes in different parts of France, ranging all the way from the humble peasant to the millionaire, and even one nobleman, and all, where not expecting company, were serving home brew, although they might have had something better in reserve. I make these statements to show what becomes of the enormous quantities of cider that are made annually in the apple regions of France.

Spraying and pruning are practically unknown among the apple growers. Leaf aphis does a lot of harm to both the trees and the fruit and codling moth runs riot undisturbed and unmolested which leads one to think they must like the flavor these insects impart to the cider.

The introduction of American cider making machinery into France has resulted in lowering the quality of the apple seeds recovered. One of the largest users of apple seeds in the United States told me last summer that the quality of the seed was going down every year. It seems the new mills break a high percentage of the seeds while the ones used formerly rarely even broke any of them. He said it now required almost double the number of pounds of seed per acre to get a good stand as formerly. The new mills extract more juice from the fruit though, so the grower is still ahead of the game.

During the last few years both apple and pear seeds have been coming from the vicinity of Steinmarkt, Austria. Large quantities of these have been collected by Fratelli Sgaravatti of Saonari (Padua), Italy which they send direct to the United States themselves or sell to exporters. They like these Austrian seeds better than those secured from France as they say they do not contain so many broken seeds. From what I could see of these apple seedlings in the nursery row, they looked exactly like the French product.

I have not completed my studies of pear and prune stocks. The prune growers use Myrobalan, St. Julien, Mirabelles and seedlings of the Prune d'Agen, the Questche or German plum, and the Rein Claude Violette. Pear seed apparently comes from the north of France, but from no particular locality.

Walnuts are universally propagated on Persian walnut seedlings. I went carefully over all the principal walnut regions of France, but saw only one man who was trying any other stock. The man was experimenting with the black walnut of the eastern United States *Juglans nigra* which he hoped might be resistant to the oak fungus *Armillaria mellea* which is killing their walnuts off wholesale.

MEETING OF THE GREAT PLAINS SECTION

Third Annual Convention

OTTAWA, CANADA

August 17 and 18, 1921

It is the policy of this Society to publish in its annual report the papers read at the sectional meetings, unless the papers are published elsewhere. This is the first time that papers of any sectional meeting have been sent to the Secretary for publication. The paper by W. T. Macoun on "History and Results of the Work in Fruit Breeding at the Central Experiment Farm," was also read at the Toronto meeting and appears elsewhere in this report. The other papers follow:

The Jewel of the North

BY W. J. BOUGHEN, *Valley River Nurseries, Valley River, Manitoba.*

Published in the Minnesota State Horticultural Society Report; Vol. 49, 328, 1921.

Some Fruits of Northeastern Asia

BY F. L. SKINNER, *Dropmore, Manitoba.*

Published in the Minnesota State Horticultural Society Report: Vol. 49, 297, 1921.

Some Difficulties in Fruit Breeding

BY M. J. DORSEY, *University Farm, St. Paul, Minn.*

Published in Scientific Agriculture: 2, 118-120, 1921.

The Possibility of the Transmission by Asexual Propagation of the High Yielding of Individual Apple Trees

BY M. B. DAVIS, *Central Experimental Farm, Ottawa, Canada.*

Published in Scientific Agriculture: 2, 120-124, 1921.

Some Factors in Handling Seed Potatoes

BY A. F. YEAGER, *Agricultural College, N. D.*

Published in the Minnesota State Horticultural Society Report: Vol. 49, 298-316, 1921.

The Russian Apple in America

By W. R. Leslie, *Morden, Manitoba.*

RUSSIA has had much of value in plant material for those parts of the prairie plains of North America characterized by long cold winters and summers noted for their hot days and cool nights, with tendency to lengthy periods of scanty rainfall. Caragana arborescens is prominent among these successful adoptions. In willows, the Russian Laurel-Leaf, Russian Golden, Niobe Weeping, and Ural are proving of widespread adaptation. The Siberian rugosa roses are now familiar in even our far northern settlements. The Siberian Almond is popular and doing well in Manitoba. However, members of the White Race are wont to consider their abode but temporary in an area in which apples are not grown, and in pleasing localities, if the king of fruits is not being grown, they are sure to attempt the varieties familiar to them in their childhood homes.

We, as horticulturists from the Northern Great Plains, are directly concerned with the varieties which may be classed as successful in that realm. Not a single one among all the old-time varieties of standard apples is suited throughout the prairies. In fact but three varieties in that category, successful apples, can yet be named.—The Siberian berried crab (pyrus baccata) and the two Saunder's Hybrids, Osman and Columbia. All three are but crab apples. Such is the state of affairs to-day. The task is to improve these vastly in point of size as well as in flavor, while still retaining their hardiness, or, in other words, their quality to thrive persistently in the regions of rigorous climate. To this end, we turn to the Russian type as being the most helpful blood for the first infusion.

To obtain a definite idea of the compass of the quantity under consideration, it is well to recall the statements of William A. Taylor, of the United States Department of Agriculture,—

" 'Russian Apple' should be restricted to the somewhat distinct group of varieties which trace to the interior of Russia and which may be roughly characterized as follows:—

"Varieties usually dwarfish are but moderately strong growers, having leaves medium to large, often very large, thick, often with an extra layer palisade cells; leaves and young wood susceptible to blight; fruit variable in size from below medium to very large, usually symmetrical and often angular, but almost invariably having a wrinkled or knotted and downy basin; color variable, ranging from greenish to clear white yellow, commonly more or less covered with brilliant blushes or stripes, rarely or never solid red, and in most varieties, particularly when grown in dry regions, covered with a pruinose bloom; flesh usually rather coarse in texture and of acid flavor, though in some varieties a mild sub-acid and in a few sweet; season of most varieties summer or fall, a few keeping well until spring when grown in the extreme north; chief use, cooking; trees resistant to extreme cold and commonly productive.

"The characters noted above are so strongly marked that they are transmitted to many of the seedlings grown in this country, such varieties as Wolf River, Patten Greening, McMahon, Dudley, and Okabena, being good examples. I have little doubt that a close study and comparsion of the trees including leaves, wood, blossoms, and fruit, would disclose other distinctive characters.

"Many of the varieties that have reached this country from Russia are clearly not of the type referred to, but belong with the thin-leaved apples common to the humid regions of Western Europe. So that the fact that a variety came from Russia does not make it "Russian" in a pomological sense".

With this generous picture of the Russian apple in mind, let us look into its immigration to this continent and somewhat into its career and fortunes since.

INTRODUCTION.

The Alexander is probably one of the first if not the first "Russian apple" introduced. It is supposed to have been shown at the September meeting of the Massachusetts Horticultural Society in 1830 by Robert Manning. Reports indicate its introduction into England from Russia in 1817.

Kenrick in 1832 recommended for trial in the United States "two highly celebrated Russian apples," one the Duchess of Oldenburg, the other Emperor Alexander or Alexander, or Aporta. Shortly after this the Massachusetts Horticultural Society imported from England the Alexander, Tetofsky, Oldenburg, and Red Astrachan. These were secured from the London Horticultural Society.

One of the first private enterprises along the line of introducing scions direct from Russia was that of A. G. Tuttle of Baraboo, Wisconsin. He obtained a number of the best Russian apples from St. Petersburg through the American Minister, Cassius M. Clay.

The United States Department of Agriculture made a large importation in 1870. These came from Dr. Edward Regel, Director of the Imperial Botanic Gardens at St. Petersburg. There were 252 kinds, but when duplicates and synomyms were accounted for there remained 202 varieties, more or less distinct. Mr. William Saunders, who was in charge of the work at Washington, had specimens of each of the whole shipment growing. For six years all available scions were cut and distributed far and wide. The Department sent out 100,000 packets in one year. The regrettable features of this trial work is that only a few deliveries received intelligent, favorable treatment, and much trouble was caused because of confusion in nomenclature.

The Iowa Agriculture College made importations between 1875 and 1880. Professor J. L. Budd of that institution received in 1879 from Dr. Regel, 72 varieties, and it is interesting to note that 14 of these do not appear in the Department of Agriculture list. Most of the variety numbers agreed with the numbers

of the Department varieties.

In the year 1882 Professor J. L. Budd of Ames, Iowa, and Mr. Charles Gibb of Abbottsford, Quebec, travelled through Russia, Poland, Germany, and Austria, studying fruit growing conditions and selecting scions. They gained a valuable store of information and the varieties of apples collected were distributed for trial throughout the Mississippi and Missouri Valleys.

The Central Experimental Farm, Ottawa, has grown many thousand of seedlings from seed secured from Russia and also from seed raised in its own Russian Apple Orchard." In 1912 it grew 50,000 seedlings from the varieties, Anis, Antonovka, Charlamoff, Hibernal, and Tetofsky. The aim in this work is to find apples of standard size suited to Canadian prairie conditions. In 1916 the young branch station at Morden, Manitoba, which is the Dominion Station for Southern Manitoba, received a shipment from Ottawa of 25,000 seedlings. A large percentage of these are thriving and a number have borne fruit.

It should occasion no surprise that one of the annoyances in importing these Russian Apples has been the confusion of nomenclature. Gibbs states that in Russia, pomology is a neglected science. A single variety might easily be found under a number of names in different parts of Russia. In some regions it was common to propagate from seed and this assured variations, even though this class of apples possess, as is in several places claimed for them, the characteristic of their seedlings showing marked similarity to the parent. Having varieties distributed in America under numbers instead of distinctive names, increased the trouble. The confusion experienced caused delay in sifting out the more useful varieties. To correct the complications the "Russian Apple Nomenclature Committee" was formed. The apples were divided into groups.

Groups based on tree characters included the Red Astrachan, Hibernal, Oldenburg, Longfield, and the Transparent type.

The groups based on fruit characters were.—Hibernal, Oldenburg, Charlamoff, Longfield, Anisim, Repka Malenka, Christmas, Antonovka, Yellow Sweet, Cross, Romna, Transparent, Anis, Golden White.

Developments

In reviewing the fortunes of these apples in America, we find that they have formed the chief basis for apple growing in the North Central States and contiguous parts of Canada.

Of the 67 varieties described in 1903 by Professor S. B. Green of Minnesota, 24 originated in Russia and 12 are northwestern grown seedlings of Russian varieties. Most of these are chance seedlings but among them are,—

Wolf River—suppose to be a seedling of Alexander originated in Wisconsin.

Patten—a seedling of Oldenburg originated in Iowa.

McMahon—a seedling of Alexander originated in Wisconsin about 1860.

Okabena—a seedling of Oldenburg originated in Minnesota in 1871.

The list of apple varieties recommended for Minnesota includes Oldenburg, Hibernal, Charlamoff, Longfield, Tetofsky, Repka Malenka, Cross, and Christmas.

The Wisconsin list is—Longfield, Anisim, Antonovka, Beautiful Arcade, Lowland Raspberry, Repka Malenka.

The Southern Manitoba list is altogether of this class of standard apples and is composed of Blushed Calville, Hibernal, Anisette, Oldenburg, Charlamoff, Ukraine, Repka Kislaga, Antonovka, Ostrakoff.

The last above-named zone is the most northerly region of the Great Plains where real accomplishment has been experienced in growing large-sized apples. Messrs. A. P. Stevenson & Sons of the Pine Grove Nursery, Morden, Manitoba, have tested over 80 varieties of Russian apples and at present have 15 varieties bearing satisfactory, profitable crops. Their orchard produces annually a good harvest, which is generally between two hundred and three hundred barrels. These people have originated several standard apple seedlings of value.

In the Rainy River District of Northern Ontario there are some home orchards in which very fair apples are grown. Dr. R. Moore of Port Frances has the reputation of being the leading fruit experimenter of the District. The varieties of apples doing best are all included in the list for Southern Manitoba.

The greatest work to be done in the further development of pomology is to provide varieties which will prove suitable for the large area of the Great Plains for which up to the present time no standard apple variety has been found. The Central Experimental Farm at Ottawa, has been spending much effort in an attempt to push the apple growing territory northward and westward in the prairie provinces. The most successful attempt has been the crossing of a number of large apples with the Pyrus baccata. Several of the first generation progeny are excellent crab apples even though none are large enough to be classed as standard apples. The hardiest of these are seedlings whose pollen parents were Russian apples. Professor W. T. Macoun, Dominion Horticulturist, reports that only two of these seedlings are perfectly hardy at all of the prairie Dominion Experimental Farms and Stations. These are the Columbia (Pyrus Baccata X Broad Green) and Osman (Pyrus Baccata X Osimoe or as it is called in Manitoba, Repka Kislaga). However, an advance has been made and Professor Mamoun states,—"After being propagated and tested on the prairies some of Dr. Saunder's hybrids have proved hardier than any other varieties of apples or crab apples tested, thus marking a stage of development in hardy apples for the prairies.

Native Home

For the sake of becoming more widely acquainted with these apples it is advantageous to review the findings of Budd and Gibb. In their scouting trip of 1882 they travelled over much of the Russian steppes and appear to have studied the orchards and fruits very closely. Professor Budd wrote a series of reports under the title of "A New Search for Iron-Clad Fruit Trees in Russia"

and reports the varieties Antonovka and Red Anis doing well in territories where winter temperatures sometimes reach as low as 46° F. He mentions orchards bearing well at northern latitudes where the trees were of such small stature as to give the impression of a dwarf species.

Mr. Gibb also makes mention of the trees being noticeably dwarfed in the far north. He found the large white autumn apple, the Antonovka, to be the foremost apple of the Russian steppes. It is the leading apple over a larger section of country than any other in Europe being grown at latitude 55 and having been known to live through 51° F. below zero and remain in fine health. In Central Rüssia this apple has been on test for over a century and perhaps several centuries. Thus it is a prairie apple suited to prairie soils.

Mr. Gibb has interesting things to say of the Anis. This name applies to a family of apples, but the seedlings are much alike in tree and fruit, as encountered in the Volga. Some of Mr. Gibb's statements follow:—

"In the southern part of the Government of Kazan, in latitude 55, the same latitude as Moscow but 430 miles to the east of it, in a continental climate, a climate of extremes, and yet 600 miles nearer the north pole than the city of Quebec, there are twelve villages where the peasant proprietors are apple growers, the chief industry, in fact, is apple growing. When we were there the little trees were loaded with fruit, yet the thermometer had been down to 40° below zero the winter previous. Five years before, during one day, the temperature of these exposed loess bluffs was -40 Reaumur or 58 below zero by Fahrenheit's themometer. These low temperatures, however, do not seem verified by the meteorological records in the city of Kazan. Hearing of these low temperatures, I looked for winter injury to the trees, but did not find any traces of it.

"The Volga is a very old apple growing region. I am told that old poems, written about the time when Rurik was upon the throne of Kiev, about 850, allude to this. The maiden whose neck was like a swan, and whose lips were like cherries, had cheeks like a Volga apple. The high color of the apples of this dry region is very striking.

"A wild rugged race of apple trees has been grown here for many centuries from seedling production."

"In Eastern Russia we find fruit growing a profitable industry in climates decidedly more severe than that of the city of Quebec. Hence we may expect to increase the area of fruit culture northward upon this continent very largely."

New Home

The prophecy of Mr. Gibb as here quoted has been partly fulfilled, but only partly. There is no doubt but what the Russian apple in America shall be more and more a vital part in evolving a northern prairie pomology. In the Budd-Hansen list of apples, as found in South Dakota bulletin 76, there are 298 varieties described, of which number 143 varieties are of Russian origin and

101 are of northwestern states origin. Of the last named class, a goodly number are seedlings of Russian varieties. Most of these new productions have been attained by chance methods. The time now is when more exact methods must be employed. Some of the Saunder's hybrids lead the crab apple orchards permanently on to new northern territory. The hardiest class of apples in the world, those which have originated in Russia, must be further used by the scientific plant breeder.

Two Russian varieties, the Oldenburg, and the Yellow Transparent, are prominent in the general commercial fruit industry of this continent. They do moderately well at Morden, Manitoba, but there are a number of Russian apple varieties possessing considerably greater hardiness.

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Seed Bed and Nursery Problems for the Fruit Breeder

By H. L. Lantz, *Iowa State College, Ames, Iowa.*

IN THE presentation of this paper it is not the purpose to outline in detail for your instruction, seed bed and nursery methods as developed by our Station in the propagation of cross bred seedlings. It is hoped that this paper, together with an open discussion of the subject will be suggestive and lead to better methods in growing valuable cross bred seedlings. I trust that these remarks and observations may stimulate further interest in the matter of scientific investigation along the lines indicated.

I feel quite sure that few fruit breeders are fully satisfied with present methods of handling seeds in storage and in the seed beds. Practically all of the scientific papers reporting seed planting records, together with the number of trees brought to fruiting age, indicate that the mortality among seedlings is very great. Possibly the question of a lack of vigor and lack of adaptability come into play to eliminate a considerable number of seedlings. However, I doubt whether the high mortality among seedlings can be accounted for altogether in this way.

Germination records often indicate a low percentage of viable seeds. This seems to vary with years. One year our records showed an average of 75 per cent germination and this year the records run as low as 25 per cent. The seed treatments were identical each year in-so-far as it was possible to make them so. This variation in the viability of the seeds might be accounted for by adverse growing conditions when the seeds were produced. Likewise the degree of viability of the pollen used in the cross fertilization might account for some variation in the seed germination and likewise incompatibility in some degree between the parents used might cut down the percentage of viable seeds.

No matter what the cause, it is believed that our present methods of handling seeds prior to the planting season and the subsequent treatment in the seed beds and nurseries, bears rigid examination with a view to improvement. Cross bred seeds are expensive to produce and in themselves have a value which cannot be reckoned in dollars and cents. At the best, it is often very difficult to secure a sufficient number of cross bred seeds to make possible a thorough genetic study of the characters which are inherited from the mongrel parentages which we are obliged to use in the fruit breeding work.

What is the Best Method for Handling Seeds

Our practice has been to allow the fruit to hang on the trees till fully or even over-mature. The seeds are then removed and each lot having the same percentage are placed in separate paper bags, labled and stored in a dry place. Early in February the seeds are placed in cloth bags, each lot being labled with an embossed zinc label. They are allowed to soak 48 hours in three or four changes of water, and then stratified in about four inches of wet sand out of doors in a well shaded place, where alternate freezing and thawing are not apt to occur. Burlap sacks placed on the stratifying bed are serviceable in holding the moisture and also the frost, and in maintaining a uniform temperature. In this connection we have several times found it difficult to hold the temperature low enough through the latter part of March and the forepart of April, in order to prevent the seeds from sprouting before the seed beds can be prepared.

We have practiced the foregoing method of seed treatment for the past four years, and as stated before, our germination records show that in some years we get high germination, and again we may get low germination.

Is this seed treatment at fault? Should apple seeds be allowed to dry out? What is the optimum moisture content that should be maintained? What method could be used to maintain an optimum moisture content where we have small lots of seeds? When should stratification take place? Is freezing necessary? What is the optimum amount of freezing that should be given? Does alternate freezing and thawing injure the embryo?

These are a few of the questions that need to be answered before we have a perfected method of handling cross bred apple and pear seed. I mention these two kinds of seeds together because they respond to the same treatment in much the same way.

The practice among nurserymen varies. One large Missouri nursery places the seed in bags which hold about one bushel each, and suspend the bag into a barrel of water. They are allowed to soak this way for about two months, the water being changed every day to prevent fermentation. The seed is then poured out on a floor and mixed with a liberal amount of damp sand, which is kept moist till planting season. No freezing is permitted during the stratification period. Other nurseries are very particular to see that freezing does occur.

Pear seed germinates much more vigorously and the seedlings with us make from 2 to 3 times as much growth per season for the first 2 or 3 years as do apple seedlings. Pear seeds apparently do not require as careful handling as do apple seeds.

Plum seed taken from the fruit and stratified immediately in sand out of doors where freezing takes place all winter, had germinnated quite satisfactorily with us. The freezing cracks the seeds at the suture and insures quick germination. Plum seeds are in no danger of molestation from mice as are apple and pear seeds.

Cherry seed handled in the same way has given us only fair

results; yet this method is the one most commonly recommended and practiced.

Grapes we find should be stratified at once after removal from the pulp, and be placed where they will freeze during the winter. Even then many of the seeds will not germinate till the second year.

Preparation of the Seed Bed

Selection of the sub-soil for the seed bed is an important matter. Rather light, friable, and well drained soil is desirable. Fall plowing, followed by plowing again in the spring as early as the ground will permit without baking or puddling, seems to be a good practice under Iowa conditions as ground plowed in the fall is usually more friable than that plowed only in the spring.

We built the seed bed up about three inches, using 1 x 6 inch boards on the sides and ends, and filling in with dirt. The beds are built 7 feet wide which permits hoeing to the center of the bed from each side. The beds run from 50 to 200 feet according to our needs. Seed beds need to be constructed so that they are level from end to end in order to avoid washing during drenching showers. This is quite an important consideration.

We do our planting as early in the spring as the ground will permit working. Otherwise apple seeds are apt to sprout which renders it difficult to plant without loss.

A planting board 8 inches wide and 7 feet long which fits just inside the seed bed frame, is fitted with 20 pegs ¾ inches long which are placed 4 inches apart. The planting board is used to level off the surface of the seed bed and to make the holes for the seeds. The rows are placed one foot apart. This system of planting puts exactly 20 seeds to the row and simplifies the work of securing accurate germination and growth records. It also facilitates the keeping of accurate tree records in the seed bed and the study of the growth and other characters of individual trees from time to time.

As the seeds are planted we find it a good practice to sand the beds about ¼ inch deep to prevent baking and surface cracking, and more important to prevent damping off. The surface of the seed bed should not be allowed to dry out during the germination period. It may become necessary to wet down the surface of the ground occasionally until the young trees begin to appear.

Careful attention is given to the labeling of each lot of seed. Embossed zinc labels are placed at the beginning and end of each seed lot.

The foregoing seed bed method is efficient for handling upwards of 20,000 seeds per year. When there are larger lots of seed to be grown, then the nursery row method will perhaps be best. However, when it is desired to obtain accurate germination records as well as vigor and health records, the seed bed method offers considerable advantages for the first two years.

Some fruit breeders recommend stratifying and freezing the apple seeds early in the winter and planting in flats in the greenhouse in February, then transplanting to the nursery row in

April. This method does offer some advantage in securing additional growth on the seedlings the first year. However, it is open to considerable objection where the number of cross bred seeds is large. It also requires close attention as the dangers of loss from damping off are by no means small, even though this disease may be controlled to a certain extent by sterilization and bottom watering.

With us the seedlings are allowed to remain in the seed bed two years, and are then transplanted to the nursery row where they remain for another two years. Two year old seedlings usually have only one long tap root with but few small side roots. The tap roots are cut off when removed from the seed bed to the nursery row with the result that the trees make a slow start after being transplanted and are none too vigorous the first year in the nursery. Would it not be feasible to cut the tap roots at one year of age, with some sharp instrument, say about the first of April before growth starts in order to secure a branched root system? A tree with branched root system seems to make a more satisfactory growth in the nursery row when transplanted from the seed bed because of the increased number of new side roots that are formed.

Our Iowa nurserymen uniformly practice cutting grafted trees back to one bud above the ground the spring following the first season's growth. This practice produces a more nearly uniform lot of trees. They are allowed to stand two seasons in the nursery row after being cut back, the trees being called "two-year cut backs", when dug.

This practice led us to do the same in 1919 with our one-year old seedlings which were growing in the seed beds at the State Fruit Breeding Farm at Charles City. These seedlings had made an average growth of from 8 to 12 inches the previous season and were often branched, having an undesirable bushy top which probably was caused by leaf hopper injury. During the season of 1919 these cut back seedlings made an average growth of 12 to 24 inches. Variation in growth was usually greater between the lots than within any given lot. The results obtained by cutting back were, we believe, not worth the work involved. The following year 1920, we allowed our one-year seedlings of the 1919 planting to grow without cutting back. The growth was equally as good if not better than that obtained on the cut backs and there was little or no difference in the type of growth. However, we laid out no experiment to determine this point, but with these two years of experience we feel like abandoning the cut back method on trees grown from seed.

What is the Value of the Original Tree?

In our work we have a great deal of evidence to indicate that a considerable percentage of the seedlings make much better trees when root grafted on common commercial stock, and better yet when top worked on two-year Virginia crab. A number of our seedlings which showed a lack of vigor in the nursery and undesirable orchard habit, became vigorous, shapely trees when top worked on Virginia crab and Wealthy. It appears that some seedlings do not have the ability to establish strong root systems.

At any rate, our experience indicates that where only a single tree of each seedling is grown, it is not possible to secure accurate data as to variety characters.

I seriously doubt whether the inheritance of characters of cross bred trees such as for instance, vigor, foliage, type, orchard habit, etc., can be accurately determined where only one or two trees of each seedling variety are grown. In our work we often find two trees propagated from the original tree of a certain cross growing side by side. worked on identical stock and both treated alike, which are quite unlike in vigor and in health of foliage. So often have we come across this thing that I am coming to place little confidence in a study of character inheritance, except where more than one or two trees of each seedling are grown. Where several trees are propagated from the original tree and these are nearly alike in type of growth and foliage, of course the evidence can be considered rather complete.

In part answer to the question as to what the original tree is worth, our Colorado Orange X Jonathan line of breeding gave us 32 original trees which were evidently lacking in vigor. 28 died, 1 ranks as a good tree in 1921, 1 ranks as average. 1 ranks fair, and 1 ranks poor. Bud wood of each of these 32 trees was secured and one tree of each seedling was budded on Virginia crab and on Wealthy in 1915 in order to save the variety, and to see whether or not the original trees which were weak growers in the nursery row would remain weak when top worked.

Ten of the 32 were budded on Virginia crab in 1915 in the nursery, and were set in the orchard in 1917. All made good average vigorous trees, several being very strong growers. Twenty-two were budded on Wealthy, and all made good vigorous trees. There is considerable variation in the vigor, size, and type of these trees, but here we have good vigorous trees when top worked, whereas, the original tree was weak and failed entirely. We have several thousand budded seedlings growing at Ames which were budded to save those seedlings which as original trees failed for the most part because of a lack of vigor.

What Shall be Discarded?

In the light of the above experience shall we discard trees in the nursery row which are lacking in vigor? Or, would it not be better to give each tree another chance by budding or grafting it on other stock? It appears from abundant evidence that the vigor and style of the original seedling apple tree is not an accurate index to the potential vigor and style of the variety. Vigor, type, health, foliage, hardiness, and characters of fruitage, may, it appears, often be considerably modified by top working on healthy, hardy stock. In fact we have abundant evidence which seems to indicate that by top working each seedling as early as it is possible to secure suitable top working wood, we can secure larger trees of better health and vigor in the majority of cases than is possible where the original trees are depended on.

Results of Fruit Culture on the Forest Nursery Station at Indian Head, Saskatchewan

By N. M. Ross, *Indian Head, Sask.*

When I was recently asked by our Secretary to prepare something for this meeting of the Official Horticultural Society I thought that possibly a brief review of what we have been doing in a small way to grow fruit on the Nursery Station at Indian Head might be of as much interest as anything else.

Our Station was not established with a view to doing any special work with fruit and we have no appropriation for developing that line. However, we received so many inquiries for information as to the varieties which may be grown under prairie conditions, that I thought it advisable to make a trial of what might prove successful so as to have some practical experience on which to base such information.

Of course we all know that currants and raspberries may be grown to perfection. Gooseberries and strawberries have also proved very satisfactory. Beyond securing a few plants of unnamed sorts from the Experimental Farm we have done nothing particular with currants. With raspberries, however, we planted a number of kinds such as Louden, Turner, Minnetonka, Shippers Pride, Sunbeam and Herbert, and later, in 1919, Ohta, Minnesota No. 4 and St. Regis. Of these the Herbert has undoubtedly proved the strongest grower and most prolific, with immense berries. The Minnesota No. 4 appears very promising and may equal the Herbert when plants are well established. We do not find that the Herbert is any less hardy than other kinds. Our canes are always laid down for winter and grown under the hill system.

We made no trial with gooseberries until 1919, when plants of Pearl, Carrie, Rideau and Downing were set out. These have all made great growth and commenced to bear well this season.

With strawberries, we started in 1906 with Dunlap and Bederwood. The former has given us good crops every season since. The Bederwood, while doing very well in certain seasons, has not been so uniformly good. We have been trying the everbearing varieties for a number of years such as Progressive, Superb, Americus and No. 1017. I cannot say that with us these have given such good results as the Dunlap. In favorable seasons with plenty of rain we have had good berries up to middle of October; but for the home garden to grow for preserving purposes we would consider the Dunlap most suitable. A very large per cent of the everbearers killed out with us last winter, while the Dunlap under same conditions came through well.

Of the plums we have tried Aitkin, Cheney, Stevensons Mammoth and the native Manitoba wild plum. Of these the Mammoth has borne heavily and produces fruit of good size and fair quality, especially for preserving. The Aitkin blossoms very early and sometimes gets caught by frost. Still our trees have for four or five seasons borne fair crops. The fruit is of good size and very

attractive appearance, but not particularly good quality. The Cheney has given us very heavy crops, three to four weeks later than Aitkin, and makes most excellent preserves. We secured quite a large number of the Hansen hybrids which have been planted now about six years and all have proved reasonably hardy. Of these the best and most prolific are Sapa, Oziya and Opata. The Sapa bears very heavily, the fruit is deep crimson and the flesh a deep red. It makes a splendid preserve of quite distinctive flavor. The Oziya is a good sized yellowish fruit of very pleasing flavor. Under Professor Hansen's advice these hybrids have been grown in bush form so that the branches may be laid on the ground for winter protection. We also got from Professor Hansen the Tokata. This seems to be more of the plum type, both in habit of growth and size of fruit. These bore fruit first in 1920 and this season show a very good crop. The fruit is larger than the Mammoth, ripening possibly a few days later. The flavor however is most distinctive, by far the best variety for eating grown here yet.

The Compass Cherry has also borne well with us for several seasons.

It would appear from our experience that there is no difficulty whatever in growing these hardy plums under our prairie conditions. Certainly sufficient quantities of these fruits could be grown on almost any farm to supply the home requirements. No doubt for best results a good shelter belt to protect the trees from wind and storm is advisable, but it is not at all a difficult matter to establish a good shelter in a very few seasons.

I was very anxious to see what could be done with standard apples and was encouraged by what I saw done by Mr. A. P. Stevenson of Morden, Manitoba. Crabs of various kinds had proved fairly successful on the Experimental Farm at Indian Head, and in 1906 I got from Mr. Angus MacKay a few seedlings of Dr. Saunders hybrids which had been sent out from Ottawa. After five or six seasons these commenced to show fruit, but most of them were very small and disappointing. One or two of the seedlings had fruit about one inch or an inch and a quarter in diameter, but these killed out after a few more seasons.. One of these seedlings appeard very hardy, but the fruit was extremely small and of no value. I, however, secured from Mr. Stevenson scions of Wealthy and Charlamoff and top worked on to this seedling. The grafts took well, but subsequently many of the Wealthy shoots killed back. This tree now stands about fourteen feet high and this season is bearing a very fair crop of both Charlamoff and Wealthy. One graft of Wealthy is bearing very heavily and the fruit is of very good size.

About the time I got the grafts I also secured from Mr. Stevenson young trees of Blushed Calville, Hibernal, Antonovka, Simbrisk, Kluvescoe, Gypsy Girl, Patten, Oldenburg and Charlamoff. These mostly grew well, but showed considerable winter killing for several seasons, and after four or five years it did not look as though we could get any results; then the trees seemed to pick up and were getting into good shape when during the winter rabbits cleaned out nearly every tree. It seemed to be impossible to do

anything against the rabbits and only those portions of the lower limbs which were wrapped with burlap escaped barking. In the spring the trees were a sorry looking lot and seemed hopeless. However, they were cut back and wounds painted and to avoid similar damage in future a six foot rabbit fence was erected all around the small orchard. The trees were badly weakened and an occasional one succumbed. However, new growth was made and the trees gradually recovered, though owing to the wounds received most of the trees appeared to get badly affected with some fungus. This season for the first time the growth looked healthy and vigorous and nearly all varieties showed more or less bloom. Late frosts, however, destroyed much of the blossoms. In spite of this a few of the trees are bearing a fair crop of very excellent apples. Particularly the Hibernal and Blushed Calville are bearing well. The Charlamoff, except those top worked, have not shown any fruit. We also have a few apples of the Gypsy Girl, Patten, Antonovka, Simbrisk and Whitney Hibrid and now feel more encouraged as to the future.

A number of years ago I secured a quantity of seed of Wealthy from Mr. Stevenson and set out 1500 or 2000 seedlings from this seed. The majority of these winter killed so badly that most of them were cut out about five years later, leaving probably 30 or 40 of the hardiest. These have not yet all fruited, but those that have are of more or less crab type, though some are very prolific with the fruit from an inch to an inch and three-quarters in diameter. One seedling tree fruiting this season for the first time is more promising, with a fruit of nearly two inches in diameter.

On the whole we are encouraged to believe that it is only a question of time until suitable kinds of standard apples can be developed which will prove successful under our conditions. While the Russian varieties above mentioned give promise of some success, I believe that eventually seedlings of these, or seedlings of specially hybridized varieties, are what we must look to for more certain results.

We must develop if possible varieties which are more hardy than these Russian sorts and particularly kinds that will not kill out in the heart wood. It appears that with our present varieties only the bark and a small layer of newer tissue keeps alive while the inner wood is dead and more or less infected with a fungus growth.

These are great opportunities for stations such as the Morden Fruit Station to do good work along these lines, and I would very much like to see a fruit breeding station established somewhere in Saskatchewan, where conditions are even less favorable, along the lines of the fruit breeding farms which have proved so valuable in Minnesota.

Greenhouse Cucumber Breeding

By W. J. STRONG, *Horticultural Experiment Station, Vineland, Ontario.*

COMPARED with other horticultural crops the greenhouse cucumber occupies a rather minor position. It is not a cheap crop to produce neither is it one that enjoys an unlimited market and can hardly be considered a staple crop such as cabbage, carrots, beans or onions. It ranks more as a luxury and is quite an aristocrat compared with its humble outdoor brothers.

Now as to the type of cucumber our market requires. The long green English type is not much in favor except in a few cases and on private estates. The market wants a cucumber that runs about eight inches long and two inches in diameter, so that 1½ dozen will pack into an eleven quart basket, but it is not altogether a matter of packing. Dealers and retailers find that the average families do not care to buy two feet of cucumber at a time. They much prefer the smaller fruits and buy them oftener.

So much for the size of cucumber required, that is comparatively easy to get, but there are other things to consider.

What is our ideal cucumber? Briefly—it should be about 8 inches long and 2 inches in diameter, straight and with even size from end to end with no neck and without a heavy shoulder or small tip. It should be dark green, smooth with white spines, or spineless, and last but not least it should set fruit freely without pollenation.

This free setting without pollenation is very important as it makes it unnecessary to resort to artificial pollenation either by hand or by bees. Artificial pollenation is laborious and expensive and bees do not work to advantage in the humid atmosphere of the cucumber house.

No pollenation, of course, means no seeds, and fruits without seeds keep in better condition on the vines than those with seeds. But seedlessness may have its disadvantages. We all appreciate seedless oranges and seedless raisins, and most of us no doubt prefer seedless cucumbers, but I know of one instance where a customer returned some seedless cucumbers with the complaint that they were not ripe.

Now it may seem that I am putting undue emphasis on the mere selling qualities of this crop, but that is really what we must keep in mind. We must produce something that the consumer wants or can be taught to want. The ordinary grower is not much interested in the principles of plant breeding. It is up to practical plant breeders to understand and be able to apply these principles and produce new fruits, vegetables and flowers, that will be of greater value or beauty than anything we have at present.

The need of the smooth small seedless cucumber must have been felt for a number of years as the original cross which has given us our new variety was made back in 1910 by Mr. A. H.

Maclennan, at that time lecturer at the Ontario Agricultural College, now Vegetable Specialist for Ontario.

In making this cross three varieties were used: First, Suttons Everyday was crossed with Fisks White Spine, then this hybrid crossed with Princess.

A brief description of each of these varieties will not be out of place.

Suttons Everyday is of the long green English type with a bottle neck. It sets fruit freely without pollenation and is consequently seedless. It has a smooth skin of dark green color, with very few black spines and bears its fruits mostly in pairs at each joint. It also has a nice delicate flavor.

Fisks White Spine is the ordinary American White Spine type. It runs 6 to 8 inches long, is somewhat rough and does not set fruit without pollenation.

Princess is rather an odd looking variety. It has rather dumpy fruit with rounded ends, has numerous black spines and bears its fruit in clusters of 4 or 5 at a joint.

These three varieties together have all the qualities we need in a cucumber.

There is the free setting of the English variety together with its smoothness, color and flavor. There is the smaller size and white spines of the White Spine variety and the rounded ends of the Princess.

Each of these varieties has also its undesirable characters such as the length and bottle neck of the English variety; the roughness and inability to set fruit without pollenation of the White Spine type and the dumpiness and coarse black spines of Princess, together with roughness and lack of free setting. Before proceeding further I should say that there are a few varieties of the White Spine type such as the Davis Perfect, that do set fruits without pollenation, but they are usually quite rough.

Having all these characters combined in the final hybrid meant a great deal of careful selection work to eliminate the undesirable qualities and to preserve those that were worth while.

We have not been able to study the plants extensively enough to decide anything as to correlation of characters. However, we find that black spine is dominant over white and spinelessness, and that freer setting appears to go with the dominant black, but we found a free setting white spine recessive and this breeds true.

By careful selection of the most desirable type of plant and fruit for the last five generations we seem to have arrived at the point where we can say that we have a distinct new variety which approximates pretty closely to our ideal, and which is coming constant from seed.

Part of the crop that we are growing this fall belongs to the tenth generation. Up to and including the fourth generation was grown at the Ontario Agricultural College.

Up to the present time we have not distributed any quantity of seed as we have not enough for general distribution, although we have sent out several small lots to growers for trial under commercial conditions. To date we have not had full reports on

these, but a few that we have heard from report quite favorably.

We have in this new variety a cucumber that runs 8 to 10 inches long and about 2 inches in diameter. It is mostly smooth and straight without any neck and carries its thickness well from end to end. It is a good dark green. It sets fruit quite freely some plants producing 30 good fruits without artificial pollenation, and about one-third of these are borne on the upright stem. Its flavor and texture are good, being rather tougher than the English parent, but not as coarse as the White Spine type.

To prevent pollenation by bees the ventilators were screened.

The plants of the earlier generations did not set their fruits freely. Out of 33 plants grown of the 5th generation only 7 set one or more fruits without pollenation and most of them had black spines, however, as before mentioned we found one white spined one which is the basis of our new variety.

We also carried on some of the black spine thinking we might possibly get a desirable white spine sort from them, but nothing worth while developed.

It would seem that the yield per plant has been increased by elimination of the poor yielders. Each new generation has been selected from the best yielding plants. In other words, we have been isolating plants possessing the free setting character from the mass of characters of the original hybrid, and along with this free setting we have managed to get the other desirable characters. Improved cultural methods and reduction in the number of seed fruits saved on each plant have also helped to increase the yield.

While the cucumber is not a staple article of food yet it is a profitable crop to grow as there is a good demand for it at good prices and we think that with improved varieties it will easily hold its own with other greenhouse crops.

ITEMS OF BUSINESS

Botanical Abstracts and Quarterly Journal

Since these two subjects were listed for the round table discussion of the social evening, the action taken on them appears under the heading "Dinner and Social Evening."

Vote of Thanks to Program Committee

The members were so well pleased with the program that a rousing vote of thanks was given to the program committee in general and to Dr. M. J. Dorsey, Chairman, in particular.

Election of Officers

The officers and committees given on Page 4 were elected for 1922.

Federation of Scientific Societies

The President and Secretary were authorized to cooperate with the officers of other scientific socieities in the arranging of programs and in drafting a constitution and by-laws for the federation of the socieities.

Report of the Committee on Resolutions

Resolved, that this Society express its obligations to the authorities of Toronto University for the use of buildings in which to hold the meetings, for the delightful entertainment of Thursday evening, and for other courtesies.

Resolved, that the Society thank the Program Committee for the excellent program of the past three days from which the members have all derived great profit.

Whereas, the United States Department of Agriculture is insufficiently supplied with funds to continue the publication of the Experiment Station Record and the Journal of Agricultural Research, publications of great value to all workers in research and education in agriculture, the cost of which is but an insignificant fraction of the money being expended by the national and state governments to forward educational and research work in agriculture, be it resolved that this Society petition the Congress of the United States, through the printing committees of the Senate and the House of Representatives, to appropriate sufficient money for printing to the United States Department of Agriculture that the publication of the Experiment Station Record and the Journal of Agricultural Research may be continued.

U. P. Hedrick, *Chairman.*
W. T. Macoun
J. C. Blair.

Partial Report of Committee on Sectional Organization

J. K. Shaw

In September 1921 a circular letter a copy of which is attached was sent to all members of the A. S. H. S. in New Jersey, Pennsylvania, Ontario and States and Provinces Northeast thereof, about 70 in number. Replies were received from 29 members well scattered over this territory. The answers to the two questions in the circular letter may be tabulated as follows:

In favor of a sectional organization	25
Opposed	2
Doubtful or non-committal	2
	29
Favoring a unit of all Eastern Canada, New England, New York, and New Jersey or larger	21
Favoring smaller units	4
Non-committal	4
	29

It appears that the members replying are strongly in favor of a sectional organization covering the entire northeastern section of the U. S. and Canada. Presumably the larger number failing to reply have no strong convictions on the matter.

This report is submitted for the consideration of the society with no definite recommendations.

Dinner and Social Evening

After the society dinner, about 50 members gathered in one of the parlors of Hart House at Toronto University and were called to order by President Chandler who asked each one in turn to stand up and be introduced to the others. Thus we all knew who the other fellow was.

The round table discussion was opened by Dr. Kraus on Botanical Abstracts. There was considerable discussion and the opinion was unanimous that the work should be continued. The point of the similarity between Botanical Abstracts and the Experiment Station Record was brought up, and a strong desire expressed that a close cooperation might be established between the two.

The question of the proposed horticultural journal was taken up and, after thorough discussion, it was voted not to attempt to start a journal at this time.

About 9 p. m. the entertainment provided for the visiting members of the American Association for the Advancement of Science by our Canadian hosts, began. A couple of bagpipers in full regalia paraded the corridors. The 48th Highlanders band in Scottish costume rendered a fine program, including United States national airs. A vocal soloist entertained in the opera house. There were contests in boxing, fencing, squash ball, indoor base ball, swimming, and water polo, and at the end of the sports refreshments were served. Our members have never before been so royally entertained and this all under one roof. Hart House is a sort of Greater Student Union and is said to be the best club house on this continent.

Obituary

Floyd H. Keister

Mr. Floyd H. Keister was born at Blacksburg, Virginia, April 23rd, 1896. He was raised on a truck farm; attended the common schools, and graduated from the Blacksburg High School in June 1915. He entered the Virginia Polytechnic Institute in 1915 and took the regular agricultural course, specializing in horticultural work. His course of training was interrupted during the war and he entered the Plattsburg Training Camp in 1918 and received a commission. At the close of hostilities he returned to the Virginia Polytechnic Institute and graduated with the degree of B. S. in Horticulture in June 1919.

While a student at the Virginia Polytechnic Institute Mr. Keister exhibited unusual seriousness of purpose. He was ambitious, hard working and a young man of exemplary character. During his college course he found time to take charge of the war garden work in the city of Roanoke, Virginia, in which capacity he gave excellent satisfaction.

Upon graduation he accepted a position at the Virginia Truck Experiment Station, Norfolk, as assistant Horticulturist, and entered upon his duties on August 11, 1919. He was energetic and painstaking in his work and had undertaken one or two problems in truck crop production which were of large local importance. He met his death by accidental drowning while surf bathing at Ocean View, Virginia, June 5, 1921.

Mr. Keister was popular with his classmates and highly regarded by his instructors. He was also very popular with the staff of the Virginia Truck Experiment Station and with the farmers and others with whom he came into contact in his professional work. His untimely death was a distinct loss to the profession.

FLOYD H KEISTER

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J C BLAIR

PROCEEDINGS

OF THE

AMERICAN SOCIETY

FOR

HORTICULTURAL SCIENCE

1922

Nineteenth Annual Meeting, Boston, Massachusetts
December 27, 28 and 29, 1922

Published by the Society
Edited by the Secretary, C. P. Close,
College Park, Maryland

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OFFICERS AND COMMITTEES FOR 1923

President	J. H. GOURLEY
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Secretary-Treasurer	C. P. CLOSE
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H. J. WEBBER

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J. W. BUSHNELL
V. R. GARDNER

A. A. A. S. COUNCIL

W. PADDOCK

NATIONAL RESEARCH COUNCIL

H. D. HOOKER, JR.

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CONSTITUTION*

ARTICLE 1

The name of this Association shall be the American Society for Horticultural Science.

ARTICLE II

The object of the Society shall be to promote the Science of Horticulture.

ARTICLE III

Any person who has a baccalaureate degree and holds an official position in an agricultural college, experiment station, or Federal or state department of agriculture in the United States or Canada, is eligible to membership. Other applicants may be admitted by vote of the executive committee.

ARTICLE IV

Meetings shall be held annually at such time and place as may be designated by the Executive Committee, unless otherwise ordered by the Society.

ARTICLE V

The officers shall consist of a President, three Vice-Presidents, and a Secretary-Treasurer, who, together with the chairman of the standing committees, shall constitute a Council to act upon all applications for membership. There shall also be an Assistant Secretary. These officers shall be elected annually by ballot.

ARTICLE VI

This Constitution may be amended by two-thirds vote of the Society at any regular meeting, notice of such amendment having been read at the last regular meeting.

BY-LAWS

SECTION 1. The President and other officers shall perform the usual duties of their respective offices. The President shall also deliver an address at each regular meeting.

SEC. 2. There shall be a Committee on Nominations consisting of five (5) members who shall be nominated and elected by ballot at each regular meeting of the Society. It shall be the duty of this committee, at the following meeting, to suggest to the Society names for officers, referees, and members of committees for the ensuing year.†

SEC. 3. There shall be an Executive Committee, consisting of three (3) members and the President and the Secretary, ex-officio. This committee shall perform the usual duties devolving upon such committee.

SEC. 4. The Committee on Nominations shall nominate referees and alternates upon special subjects of investigation or instruction, which may be referred to its consideration by the society. The duties of these referees shall be to make concise reports upon recent investigations or methods of teaching in the subjects assigned them, and to report the present status of the same.

SEC. 5. There shall be a Committee on Program, consisting of seven (7) members, of which the Secretary shall be one. This committee shall have charge of the scientific activities of the Society, except as otherwise ordered by the Society.

SEC. 6. The annual dues of the Society shall be two dollars and fifty cents.

SEC. 7. Ten members of the Society shall constitute a quorum.

*The Constitution and By-Laws as amended from time to time.
†Since 1913 two lists of candidates have been required.

TREASURER'S REPORT FOR 1922

VOUCHER NO.	1922	CR.			
(1)	Jan. 4	Stamps			$ 1.00
	Jan. 5	Expenses of Secretary Close in attending the Toronto meeting Dec. 28-30, 1921			64.32
(2)	Jan. 6	Torsch & Franz Badge Co., Baltimore, Md., 100 Buttons for Toronto meeting			4.60
	Jan. 13	Stamps			1.00
	Jan. 21	Stamps			1.00
	Feb. 6	Stamps			1.00
	Feb. 17	Stamps			1.00
	Feb. 20	Telephone toll to The Telegraph Printing Co., Harrisburg, Pa.			1.15
(3)	Feb. 25	The Telegraph Printing Co., Harrisburg, Pa.			
		350 Programs for 1921 meeting	$17.50		
		Postage	.21	$17.71	
		Credit on telephone toll of Dec. 12, 1921		.90	
					16.81
(4)	Feb. 28	Expressage on letterheads and envelopes from Geneva, N. Y.			1.11
	Mar. 1	Stamps			1.00
(5)	Mar. 1	W. F. Humphrey, Geneva, N. Y.			
		1600 letterheads		$7.25	
		1700 envelopes		8.25	
					15.50
	Mar. 9	Telephone toll to The Telegraph Printing Co., Harrisburg, Pa.			1.40
	Mar. 10	Stamps			1.00
(6)	Mar. 11	Charles G. Stott & Co., Inc., Washington, D. C. 600 No. 70 Columbian clasp envelopes			9.45
	Mar. 20	Stamps			1.00
	Apr. 10	Stamps			1.00
	Apr. 25	Stamps			5.00
	May 3	Stamps			1.00
	May 4	Stamps			1.00
	May 8	Stamps			1.00
	May 12	Stamps			1.00
	May 13	Stamps			2.00
	May 15	Stamps			1.00
	May 22	Stamps			1.00
	May 26	Stamps			1.00
(7)	June 3	The Telegraph Printing Co., Harrisburg, Pa.,			
		400 Reports for 1921—279 pages and cover	$585.81		
		2 half-tone cuts	7.50		
		2 inserts on coated paper	6.40		
		Postage and mailing	37.71		
				$637.42	
		Allowance on 'phone call Feb. 20	$ 1.15		
		Allowance on 'phone call Mar. 9	1.40		
				2.55	
					$634.87
	June 20	Stamps			1.00
	Aug. 22	Stamps			1.00
	Oct. 20	Stamps			6.00
	Nov. 22	Telegram to M. J. Dorsey, Morgantown, W. Va.			.53
	Nov. 28	Stamps			1.00
	Dec. 2	Stamps			3.00
	Dec. 6	Stamps			1.00

(8) Dec.	7	The University Press, College Park, Md.,		
		500 envelopes	$ 2.50	
		450 programs, 1922 meeting	15.00	
		Corrections	1.00	
				$18.50
Dec.	13	Stamps		1.00
Dec.	27	To balance		351.84
		Total		$1157.08

1922 DR.

Jan.	1	By Balance	$ 243.08
Jan.	1	Miss Susie Chase, Port William, N. S., 1921 report	2.50
Jan.	1	New Botanical Garden, Bronx Park, N. Y. City, reports 1918, 1919, 1920	5.50
Jan.	1	Landbouwhoogeschool, Wageningen, Holland, reports 1905 to 1918 inclusive except 1911	13.50
Jan.	6	C. G. Atwater, New York, N. Y., reports 1920 and 1921	5.00
Jan.	6	West Virginia Experiment Station, Morgantown, W. Va., report for 1920	2.50
Jan.	9	McGill University, Montreal, Quebec, report for 1919	1.50
Jan.	9	P. L. Keene, Brookings, S D., reports for 1912 and 1913	2.00
Jan	12	Experiment Station, Hood River, Oregon, report for 1920	2.50
Jan.	26	Purdue University, Lafayette, Ind., reports for 1916, 1917, 1918, 1919 and 1920	8.50
Feb	1	R. A. Marter, Bradford Woods, Pa., report for 1920	2.50
Feb.	1	Experiment Station, West Raleigh, N. C., reports for 1915, 1916, 1917, 1918, 1919, 1920	9.50
Feb	1	P. A. Harvey, Rathdrum, Idaho, reports for 1918, 1919	3.00
Feb	1	Mass Horticultural Society, Boston, Mass reports for 1919 and 1920	4.00
Mar.	8	Wheldon & Westley, Ltd., London, England, reports 1917 and 1918	3.00
Apr	5	University of Idaho, Moscow, Idaho, reports for 1916, 1917, 1918, 1919 and 1920	8.50
Apr.	10	Walter Buddin, University College, Reading, England, report for 1920	2.50
Apr.	10	W B. Gebhardt, Macdonald College, Canada, report for 1918 and 1919	3.00
Apr.	20	Wheldon & Westley, Ltd., London, England, report for 1920	2.50
May	2	Experiment Station, Summerland, B. C., report for 1919	1.50
May	12	F. W. Faxon & Co., Boston, Mass., 2 reports for 1921	5.00
May	16	Purdue University, Lafayette, Ind., report for 1921	2.50
May	20	Georgia Experiment Station, Experiment, Ga., reports for 1921 and 1922	5.00
May	24	Brooklyn Botanic Garden, Brooklyn, N. Y., report for 1921	2.50
May	25	Virginia Agricultural Experiment Station, Blacksburg, Va., report for 1921	2.50
May	26	Seattle Public Library, Seattle, Washington, report for 1921	2.50
May	26	Cornell University, Ithaca, N. Y., report for 1921	2.50
May	26	Southern Oregon Experiment Station, Talent, Oregon, report for 1921	2.50
May	29	Kentucky Agricultural Experiment Station, Lexington, Ky., report for 1921	2.50
June	1	University of Vermont, Burlington, Vt., report for 1921	2.50
June	1	University of Maine, Orono, Me., report for 1921	2.50
June	1	Ohio State University, Columbus, Ohio, report for 1921	2.50
June	6	Licinio Capelli, Bologna, Italy reports for 1916, 1917, 1918, 1920 and 1921	9.50
June	9	Arnold Arboretum, Jamaica Plain, Mass., report for 1921	2.50
June	12	Mass. Horticultural Society, Boston, Mass., report for 1921	2.50
June	13	State College of Washington, Pullman, Wash., report for 1921	2.50

June 13	New Mexico College of A. & M. Arts, State College, N. M., report for 1921	2.50
June 15	A. C. McClurg & Co., Chicago, Ill., report for 1921	2.50
June 16	Pensylvania State Dept. of Agriculture, Harrisburg, Pa., report for 1921	2.50
June 16	Louisiana University, Baton Rouge, La., report for 1921	2.50
June 17	G. E. Stechert & Co., New York, N. Y., report for 1921	2.50
June 17	University of Minnesota, St. Paul, Minn., report for 1921	2.50
June 21	Mass. Agricultural College, Amherst, Mass., report for 1921	2.50
June 22	Utah Agricultural College, Logan, Utah, report for 1921	2.50
June 23	Leland Stanford, Jr., University, Stanford University, Calif., report for 1921	2.50
June 27	University of Nebraska, Lincoln, Neb., report for 1921	2.50
June 30	Iowa State College, Ames, Iowa, report for 1921	2.50
June 30	Hawaii Agricultural Experiment Station, Honolulu, Hawaii, report for 1921	2.50
Aug. 21	University of Missouri, Columbia, Mo., report for 1921	2.50
Aug. 21	Kansas State Agricultural College, Manhattan, Kansas, report for 1921	2.50
Aug. 21	University of California, Berkeley, Calif., 3 reports for 1921	7.50
Aug. 21	Colorado Agricultural College, Fort Collins, Col., report for 1921	2.50
Aug. 21	Department of Agriculture, Ottawa, Canada, reports for 1920 and 1921	5.00
Aug. 21	N. D. Zuber, Little Rock, Ark., report for 1921	2.50
Aug 21	C. A. Perry, Greenleaf, Kans., report for 1921	2.50
Aug. 21	Oregon Agricultural College, Corvallis, Oregon, report for 1921	2.50
Sept. 30	The Marble Laboratory, Inc., Canton, Pa., reports for 1905 to 1921 inclusive, except for 1911	20.00
Oct. 24	University of Wisconsin, Madison, Wis., report for 1921	2.50
Nov. 23	Isawo Namikawa, Kyoto Imperial University, Kyoto, Japan, reports for 1905 to 1919 inclusive, except for 1907 and 1911	14.00
Nov. 23	Dr. R. Florin Riksmusseets, Paleobotamska, Avdelning, Stockholm, Sweden, reports for 1914 and 1918	2.50
Dec. 4	Isawo Namikawa, Kyoto, Japan, report for 1920	2.50
Dec. 4	Y. Shima, Kuroishi, Aonoriken, Japan, reports for 1905 to 1921 inclusive, except those for 1907 and 1911	19.00
Dec. 7	Paul Work, Ithaca, N. Y., reports for 1917 and 1918	3.00
Dec. 27	Dues collected since 1921 meeting	657.50
	Total	$1157.08

Respectfully submitted,
C. P. Close, *Treasurer*.

The Auditing Committee reported that it had examined the accounts of the Treasurer and found them to be correct.

R. D. Anthony,
V. R. Gardner,
W. S. Brown,
Auditing Committee.

ANNUAL MEETING AT BOSTON, MASSACHUSETTS

December 27, 28, and 29, 1922

President Blair called the meeting to order and presided throughout the sessions, except occasionally for a short time when he called the vice-president to the chair. The sessions were well attended, and about 85 members were present during the meeting though not all in attendance at any one session. The program was crowded, there being 57 papers besides committee reports, but the President kept things moving and each session's papers were handled in their allotted time. The discussions were snappy and some had to be cut short, because of lack of time.

This was pronounced one of our very best meetings.

Effects of Shading Some Horticultural Plants*

By H. R. Kraybill, *Experiment Station, Durham, N. H.*

Introduction

WORK upon this subject was begun by Professor J. H. Gourley in 1917 as a part of the general project of the Department of Horticulture dealing with the factors affecting fruit bud formation. In 1920, at the time the writer became associated with the work, a cooperative project was undertaken between the departments of Horticulture and Agricultural Chemistry. The analyses reported for the year 1919 were made by Mr. Heman Fogg to whom acknowledgements are due for this aid.

The object of the work has been to study the effect of shading, or reduction of sunlight intensity upon fruit bud formation in horticultural plants. On account of the limited data regarding conditions associated with fruit bud formation, it seemed wise to include other material for comparison such as a pair of alternate bearing Yellow Transparent apple trees, and apple trees ringed to induce fruit bud formation. The desirability of having more information concerning the chemical conditions associated with fruit bud formation previous to a study of the effects of shading, has led to the confinement of the work of the last two years to material other than the shaded trees. It seemed wise, therefore to report at this time the results obtained in 1919 and 1920, even though it is recognized that the data are limited.

*For report of effect on leaf structure, growth, fruit bud formation, etc., see J. Gourley, Proc. Amer. Soc. Hort. Sci., 1920, p. 256 and Gourley and Nightingale Tech. Bull No. 18, N. H. Agr. Exp. Sta., 1921.

Materials

The following material was used in the work: 1. Oldenberg apple trees 12 years old shaded and unshaded for two years. 2. Elberta and Carman peach trees shaded and unshaded for two years. 3. McIntosh apple trees 8 years old ringed and unringed. 4. A pair of alternate bearing Yellow Transparent apple trees, one bearing and one non-bearing during the same year.

Methods†

Sampling. Duplicate samples composited from the last two years' growth selected from all parts of the trees of each treatment, were taken. The samples were immediately placed in weighed tightly stoppered glass bottles taken to the laboratory and weighed at once.

Nitrogen. The nitrogen determinations were made upon the fresh samples by the Kjeldahl method modified to include nitrates (1).

Moisture. The samples were clipped up into very thin peices by means of a pruning shear and then dried to constant weight in vacuum.

Carbohydrates. The twigs were cut up into thin pieces and at once immersed in hot alcohol to which precipitated calcium carbonate had been added to neutralize acidity. The samples were then heated for an hour at approximately 68° C. After standing for at least a few days the alcohol was poured off of the residue and filtered into a volumetric flask. The residue was repeatedly heated with small portions of 80 per cent alcohol and after cooling the extract was filtered off. The extracts were combined and made to volume. The residue was dried and then ground in a mill to a fine powder. Aliquots of the residue were extracted with warm water, 40°C., and the extract was combined with a similar aliquot of the alcohol extract after evaporating off the alcohol. The combined extracts after being cleared with lead acetate made to volume and deleaded with sodium oxalate were used for the estimation of the free reducing substances and sucrose. The residue from the water extraction was used for the starch and acid hydrolizable material determination.

Sucrose. Aliquots of the cleared solution used for the free reducing substances were hydrolized for the estimation of sucrose. In 1919 the Hertzfeld modification of the Clerget method (2) was used and in 1920 the citric acid method of Davis and Daish (3).

Starch. In 1919 the official method (1) was used, while in 1920 the taka-diastase method (4) was used. Instead of hydrolyzing the solution resulting from the action of the taka-diastase which contained maltose and glucose the reducing power of the solution was estimated directly after clearing with lead acetate and de-leading. Blank determinations were run with the enzyme and the temperature and time of action of the enzymes were controlled

†For the methods of shading, etc., see Gourley, J. H. and Nightingale, G. T., Tech. Bull. No. 18, N. H. Agr. Exp. Sta.

very accurately. Because of the different methods used in the two years work the results for starch are not comparable in the two years.

Acid Hydrolyzable Material. The residue from the estimation of starch was boiled with 142 cc. of water and 8 cc. of concentrated hydrochloric acid, sp. gr. 1.19, for two and one-half hours. After cooling, neutralizing, clearing with lead acetate and de-leading, the reducing power of the solution was determined.

Determination of Reducing Power. The reducing power of all of the solutions in the estimation of carbohydrates was determined by a combination of a modification of the Bertrand and the Munson and Walker methods (8).

Expression of Results. All results for the different carbohydrates are expressed as per cent of glucose. The determinations of the carbohydrates are not absolute and it should be remembered that they are used with the significance as stated here.

Effects of Shading

In the spring of 1917 two twelve-year-old Oldenburg apple trees, which bloomed heavily, were shaded with cotton cloth. Two similar trees were reserved for checks. In 1918, there was only a light bloom on both shaded trees, and in 1919 one shaded tree had eight blossoming spurs and the other had none, while the check trees had a 60 to 75 per cent bloom. In 1919 and 1920, two peach trees, one Carman and one Elberta, were covered with cloth shades. Observations in 1920 and 1921 showed more fruit buds formed on the unshaded than on the shaded trees. In all cases with the apple and the peach, shading reduced fruit bud formation.

Table number 1 shows the effect of shading upon the composition of the last two years' growth of the Oldenburg apple tree and the last years' growth of the Carman and Elberta peach. Composite samples were taken from the Elberta and Carman peach trees.

Table No. I.

Composition of Last Two Years' Growth of Shaded and Unshaded Oldenburg Apple Trees and of the Last Year's Growth of Elberta and Carman peach Trees. Carbohydrates Expressed in per cent of Dextrose. All Results are Averages of at Least Two Closely Agreeing Determinations and are Expressed Upon the Fresh Weight Basis.

Material	Date of sampling	Treatment	Dry Matter per cent	Total Nitrogen per cent	Free Reducing substances per cent	Starch per cent	Acid Hydrolyzable material per cent	Sucrose per cent
Oldenburg	June 26, '19	Shaded	40.46	0.44	0.28	5.51*	....	....
Oldenburg	June 26, '19	Unshaded	45.30	0.26	0.39	...*	....	....
Oldenburg	July 21, '19	Shaded	39.15	0.39	0.18	3.23	....	....
Oldenburg	July 21, '19	Unshaded	49.66	0.28	0.25	8.32	....	....
Peach	Sept. 3, '20	Shaded	37.21	0.37	1.06	0.54	7.37	0.11
Peach	Sept. 3, '20	Unshaded	39.31	0.31	1.36	0.74	7.97	0.20

*Acid hydrolysis method used for these starch determinations.

The analyses in Table No. 1 show tnat on June 26 and July 21 the unshaded Oldenburg apple trees, which were forming more fruit buds than the shaded trees, were lower in moisture and total nitrogen and higher in free reducing substances and starch. On September 3, the unshaded peach trees which formed more fruit buds were slightly lower in moisture and total nitrogen and slightly higher in free reducing substances, sucrose and starch. The amount of acid hydrolyzable material is about the same in the shaded and unshaded. The same relationships are shown when the results are expressed upon the dry weight basis.

TABLE No. II.

Composition of the Last Two Years' Growth of Two Alternate Bearing Yellow Transparent Apple Trees. Carbohydrates Expressed in Per cent of Dextrose. All Results are Averages of at Least Two Closely Agreeing Determinations and are Expressed Upon the Fresh Weight Basis.

Marterial	Date of sampling	Performance	Dry Matter per cent	Total Nitrogen per cent	Free Reducing substances per cent	Starch per cent	Acid Hydrolyzable material per cent	per cent Sucrose
Tree No. 44	June 27, '19	Bearing	37.98	0.29	0.42	5.78*	....	..
Tree No. 37	June 27, '19	Non-bearing	44.10	0.24	0.34	2.84?*	....	....
Tree No. 44	July 24, '19	Bearing	43.49	0.27	0.25	6.05*	....	....
Tree No. 37	July 24, '19	Non-bearing	50.39	0.30	0.19	10.05*	....	....
Tree No. 37	April 10, '20	Bearing	50.75	0.42	1.46	0.83	9.43	0.21
Tree No. 44	April 10, '20	Non bearing	52.16	0.35	....	0.40	9.77	.
Tree No. 37	July 9, '20	Bearing	38.94	0.25	0.79	0.25	7.60	0.13
Tree No. 44	July 9, '20	Non-bearing	45.82	0.23	0.74	1.33	9.28	0.04

*Acid hydrolysis method used for these starch determinations.

ALTERNATE BEARING YELLOW TRANSPARENT APPLE TREES

Table No. 2 shows the composition expressed on the fresh weight basis of the last two years' growth of two alternate bearing Yellow Transparent apple trees bearing in different years. On June 27, and July 24, 1919, and July 9, 1920, the non-bearing tree which was forming fruit buds was lower in moisture, total nitrogen and free reducing substances, and higher in starch. On April 10, 1920, the bearing tree was slightly higher in moisture, total nitrogen and starch, than the non-bearing tree. The same relations hold when the results are expressed on a dry-weight basis.

EFFECT OF RINGING ON JUNE 1

In 1919, three seven-years-old McIntosh apple trees were ringed about June 1, and three similar trees were reserved for checks. The ringing was done with a pruning knife by removing from the trunk a band of the bark about one-fourth of an inch wide about six inches from the surface of the ground. In 1920, the ringed trees showed much more bloom than the non-ringed.

In 1920, the ringing experiment was repeated by using an entirely new set of McIntosh apple trees. Table No. III shows the effect of ringing upon fruit bud formation. The counts were made in 1921. Table No. IV. shows the percentage of spurs blossoming and non-blossoming on each year's growth on the ringed and the non-ringed trees. In the non-ringed trees the percentage of spurs blossoming is greater on the older part of the branches. This is also true for the ringed trees, but to a smaller degree. The increase in per cent of spurs blossoming is smaller on the older part of the branches. If we calculate the increase of the spurs blossoming of the ringed trees over the non-ringed in per cent of the spurs which failed to form fruit buds in the non-ringed, we find in the third year's growth an increase of 72 per cent, in the fourth year's growth an increase of 95 per cent, and in the fifth year's growth an increase of 88 per cent. The effect of ringing in inducing fruit bud formation is apparently just as large if not larger in the spurs of the older parts of the tree.

TABLE NO. III.

Relative Number of Blossoming and Non-Blossoming Spurs on Ringed and Non-Ringed McIntosh Apple Trees the Year After Ringing. Ringed June 1, 1920.

	Third Year Growth No. of spurs		Fourth Year Growth No. of spurs		Fifth Year Growth No. of spurs		Sixth Year Growth No. of spurs		Seventh Year Growth No. of spurs	
Treatment	Blossoming	Non-Blossoming	Blossoming	Non-Blossoming	Blossoming	Non-Blossoming	Blossoming	Non-Blossoming	Blossoming	Non-Blossoming
Ringed										
Tree No. 1..	20	5	23	0	38	3	22	0	17	1
Tree No. 2..	37	10	22	1	18	0	4	0	..	..
Tree No. 3..	36	19	24	1	19	0	..	..	..	..
Unringed										
Tree No. 4..	5	37	19	15	13	8	..	..	..	..
Tree No. 5..	0	57	5	35	33	12	..	..	..	..
Tree No. 6..	6	70	14	13	15	13	..	..	..	..
Totals										
Ringed Trees	93	34	69	2	75	3	26	0	17	1
Unringed Trees	11	164	38	63	61	33	..	..	..	..

TABLE No. IV.

Percentage of Spurs Blossoming and Non-Blossoming on Ringed and Non-Ringed McIntosh Apple Trees the Year After Ringing. Ringed June 1, 1920.

Treatment	Third Year Growth		Fourth Year Growth		Fifth Year Growth		Sixth Year Growth		Seventh Year Growth	
	Blossoming per cent	Non-Blossoming per cent	Blossoming per cent	Non-Blossoming per cent	Blossoming per cent	Non-Blossoming per cent	Blossoming per cent	Non-Blossoming per cent	Blossoming per cent	Non-Blossoming per cent
Ringed trees	73	27	97	3	96	4	100	0	94	6
Non-ringed trees	6	94	38	62	65	35	..	..	..	..
Increase of ringed over non-ringed trees	67	..	59	..	31	..	..	..	..	..

Table No. V shows the composition of the last two years' growth of ringed and non-ringed McIntosh apple trees. On June 26 and July 8 about a month after ringing, the ringed trees which formed fruit buds much more abundantly than the non-ringed, were lower in moisture and total nitrogen and higher in free reducing substances and starch. On June 1, 1920, at the time the ringing was done, the composition of the samples from the two sets of trees was very much alike. On July 25, 1919, and September 4, 1920, almost two and three months respectively after ringing, the samples from the ringed trees showed about the same nitrogen content as those from the non-ringed trees, but were higher in starch and dry matter. On March 31, 1921, the year following ringing, the samples from the ringed trees were higher in moisture and total nitrogen and had about the same starch content as the non-ringed. The same relations hold when the results are expressed upon the dry weight basis.

TABLE NO. V.

Composition of Last Two Years' Growth of Ringed and Non-Ringed Eight-Year-Old McIntosh Apple Trees. Carbohydrates Expressed as Per Cent of Dextrose. All Results Averages of at Least Two Closely Agreeing Determinations and are Expressed Upon the Fresh Weight Basis.

Treatment	Date of sampling	Dry Matter per cent	Total Nitrogen per cent	Free Reducing substances per cent	Starch per cent	Acid Hydrolyzable material per cent	Sucrose per cent
Ringed	June 26, '19	43.19	0.27	0.69	1.40?*	....	....
Non-ringed	June 26, '19	36.91	0.36	0.42	2.40?*	....	....
Ringed	July 25, '19	54.30	0.28	0.22	13.10*	....	....
Non-ringed	July 25, '19	49.49	0.26	0.22	7.22	...	....
Ringed	June 1, '20	47.02	0.26	0.60	0.24	10.11	0.14
Non ringed	June 1, '20	46.40	0.26	0.53	0.23	9.85	0.05
Ringed	July 8, '20	47.11	0.20	0.86	1.27	10.29	0.10
Non-ringed	July 8, '20	45.00	0.22	0.69	0.53	10.25	0.08
Ringed	Sept 4, '20	52.27	0.25	0.52	2.09	8.14	0.09
Non-ringed	Sept. 4, '20	42.57	0.24	0.50	1.17	6.87	....
Ringed	Mar. 31, '21	46.71	0.61	....	0.62	7.36	....
Non-ringed	Mar. 31, '21	50.58	0.53	....	0.68	5.90	....

*Acid hydrolysis method used for these starch determinations.

DISCUSSION

In the cases where fruit bud formation was decreased by shading and increased by ringing, associated with the change in fruit bud formation, there was a change in the carbohydrate and nitrogen relationships. Kraus and Kraybill (7) have pointed out four conditions of carbohydrate-nitrogen relationships in the tomato under varying degrees of vegetation and reproduction. Under one of these conditions when there is present a fair supply of available nitrogen, and the opportunity for carbohydrate production, so that only a portion of the carbohydrates are used in vegetative extension, with the result that considerable amounts of carbohydrates accumulate as reserves, the plants are fruitful. The Oldenburg apple trees previous to shading were very fruitful and apparently in the above stated condition. Either a reduction of the opportunity for carbohydrate synthesis, or an increase in the available nitrogen when the plants are in this condition could lead to another condition pointed out by Kraus and Kraybill where there is present an abundance of available nitrogen and carbohydrates, but since both are used up in vegetative extension, only very small amounts of carbohydrates accumulate as reserves. In this latter condition the plants are non-fruitful. Without data to show the effect of shading on either the carbon assimilation or the intake of nitrogen, it is useless to speculate. However, the decreases in fruit bud formation under the conditions of shading are associated with an increase in moisture and total nitrogen, and a decrease in dry matter and available carbohydrates. These results are in harmony

with the work of Kraus and Kraybill. The results are also similar to those of Harvey and Murneek (5) who obtained decreased fruit bud formation. These non-ringed trees are apparently in the

In the case of the McIntosh apple trees, the unringed trees were only slightly fruitful. Ringing similar trees greatly increased fruit bud formation. These non-ringed trees are apparently in the condition represented by the group having a good supply of available nitrogen, and the opportunity for carbohydrate synthesis, so that there is a chance for carbohydrate accumulation and the plants are fruitful. Apparently they represent that end of this group where the nitrogen supply is greater and carbohydrate accumulation and fruitfulness less. Theoretically, conditions which could lower the supply of available nitrogen, or raise the supply of available carbohydrates, should make them more fruitful. They actually are more fruitful and there is associated therewith a lower moisture and total nitrogen content and a higher content of dry matter. These results are in harmony with the results of Kraus and Kraybill (7).

During the time of most active fruit bud differentiation in the alternate bearing Yellow Transparent apple trees, the non-bearing were lower in moisture and total nitrogen and higher in avaiable carbohydrates. This is in accord with the results of Hooker (6).

Summary

1. Shading 12-year-old Oldenburg apple trees for two seasons reduced the fruit bud formation to almost zero, while at the same time the unshaded trees showed approximately 65 per cent fruit bud formation. Samples of the last two years' growth of shaded and unshaded Oldenburg apple trees on June 26 and July 31, show that the shaded were much higher in moisture and total nitrogen, and decidedly lower in free reducing substances and starch.

2. The shading of Corman and Elberta peach trees for two years considerably reduced the number of fruit buds formed. Samples of the last two seasons' growth taken on September 3, show that the moisture and total nitrogen content were higher and the free reducing substances, sucrose, starch and acid hydrolyzable material were lower in the shaded than the unshaded trees.

3. Samples taken on June 27 and July 24 of 1919 and July 27, 1920, of the last two years' growth of two alternate bearing Yellow Transparent apple trees having their bearing year in different years, show that the bearing trees are slightly higher in moisture and total nitrogen and lower in starch. Similar samples taken on April 10, 1920, show that the bearing trees were slightly higher in moisture, total nitrogen and starch at this time.

4. Ringing eight year old McIntosh apple trees on June 1 resulted in an increase of 67 per cent in the number of spurs forming fruit buds on the third year's growth, 59 per cent on the fourth year's growth and 31 per cent on the fifth year's growth. The increase in per cent of spurs forming fruit buds represents 72 per cent of the spurs in the third year's growth, 95 per cent in the fourth year's growth and 88 per cent in the fifth year's growth which failed to form fruit buds in the non-ringed trees.

5. Samples of the ringed and non-ringed trees taken June 1 at the time of ringing, show that the trees of each lot were very similar in composition. Samples of the last two years' growth taken June 26, July 5, and July 8, show that the ringed were lower in moisture, slightly lower in total nitrogen, slightly higher in free reducing substances and sucrose, and much higher in starch. Samples taken on September 4 show that the ringed were lower in moisture, approximately the same in total nitrogen and free reducing substances, and higher in starch and acid hydrolyzable material, than the non-ringed trees. On March 31 the year following ringing, the ringed were higher in moisture and total nitrogen and practically the same in starch content as the non-ringed.

Conclusions

During the time of most active fruit bud formation in the alternate bearing Yellow Transparent apple trees, there is a condition of relatively lower moisture and total nitrogen and higher starch content in the trees which are non-bearing and forming fruit buds, than in the trees which are bearing fruit and not forming fruit buds. Likewise increased fruit bud formation induced by ringing apple trees, is associated with a decrease in moisture and total nitrogen and an increase in free reducing substances, sucrose and starch. The shading of apple and peach trees resulting in decreased fruit bud formation is associated with an increase in moisture and total nitrogen and a decrease in free reducing substances, sucrose and starch. These results are in accord with the work of Kraus and Kraybill, Hooker, Harvey, Murneek, and others.

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Light in Relation to the Growth and Chemical Composition of Some Horticultural Plants

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INTRODUCTION

THE importance of length of day in relation to the type of growth made by plants has been recently emphasized by Garner and Allard[1]. From their results they found it is possible to place most of the plants with which they worked into two main groups: (1) those which produce blossoms and seeds under light conditions approximating a relatively short, (7-hour) day, but which when the length of their day is increased become strongly vegetative and unfruitful, and (2) those which require a long, (14-hour) day to be reproductive and which become weakly vegetative when the length of the day is shortened. Many investigations including those of Kraus and Kraybill[2] have indicated that the carbohydrate content of plants in relation to the amounts of nitrogen available, strongly influence the type of growth which is made. It is the purpose of this paper to outline some of the growth conditions and associated chemical changes within plants, when exposed for various lengths of time to light.

CHEMICAL METHODS

Preparation of Samples for Analysis. The stems of several plants were selected from any particular series which was to be analyzed. The stems were cut into one-half inch pieces, dried in a vacuum oven at 80° C. and ground so that all particles would go through a sieve with 100 meshes to the inch. All traces of fat were removed by extraction with anhydrous, alcohol free, ether.

Total Sugars. Sugars were extracted with 90 per cent alcohol, evaporated in vacuum at 50° C. to a thick syrup, taken up in a little water, cleared with basic lead acetate, deleaded with Na_2SO_4, and boiled for 45 minutes with 2½ per cent HCL.

Starch and Dextrin. Starch was digested with saliva at 38° C. after which the hot water extract was boiled for 2½ hours with 2½ per cent HCL.

Hemicellulose. A 2½ per cent HCL solution was added to the residue left after extracting sugars, starch and dextrin, and was boiled for 2½ hours.

[1]Garner, W. W. and Allard. H. H. Effect of the Relative Length of Day and Night and Other Factors of the Environment on Growth and Reproduction in Horticultural Plants. Jour. Agric. Res. Vol. XVIII, No. 11, March 1, 1920.

[2]Kraus, E. J. and Kraybill, H. R. Vegetation and Reproduction With Special Reference to the Tomato. Oregon Sta. Bul. 149, January 1918.

Determination of Reducing Power. In all cases after hydrolyzing with acid, the solutions were made neutral with NaOH. The reducing power for all the carbohydrates was determined by the Shaffer titration method and the results are calculated as dextrose.

Total Nitrogen. The Kjeldahl method modified to include nitrates was employed to determine total nitrogen.

Nitrate Nitrogen. De Varda's method was used in determining nitrate nitrogen.

Insoluble Nitrogen. The Kjeldahl method was used to determine the total nitrogen in the residues left after extraction of soluble nitrogen with cold water.

Soluble Nitrogen. The soluble nitrogen was determined by obtaining the difference between the total nitrogen and the insoluble nitrogen. Also the soluble nitrogen not including nitrates was found by deducting nitrate nitrogen from total soluble nitrogen.

Microchemical. Fresh tissue was always used and the usual tests were employed for sugars, starch, nitrates and insoluble forms of nitrogen. The iodine-potassium-iodide method gave the best results in testing for insoluble forms of nitrogen. Substances dissolved in the cell sap were removed by heating the sections first in hot water and then in absolute alcohol before treatment with iodine-potassium-iodide. Tissue containing insoluble forms of nitrogen, protein in a large part, gives a yellowish precipitate upon the addition of iodine-potassium-iodide.

Experimental Data on Tomatoes

On May 22, 1922, vigorous seedlings of the Bonny Best Tomato, then about 4 inches tall, were shaken free from the rich, loamy soil in which they were growing and the roots carefully washed with water. They were then transplanted, three to a pot, into eight-inch pots filled with quartz sand. Two nutrient solutions were employed; one contained nitrates and in this solution the plants could be grown to full maturity and the fruiting condition. The other nutrient solution contained no nitrogen, but when a nitrate was added to it, growth was to full maturity and the fruiting condition. Distilled water was used for watering the minus-nitrate, and lake water for the plus-nitrate sand cultures. The plants were insured a constant and unfluctuating supply of moisture by keeping the saucers, in which the pots were set, full of water. An abundant supply of nutrient solution was maintained in the sand, but no endeavor was made to record the exact amount of nutritive elements which the plants received.

On June 7, 15 days after setting in the sand cultures, the tomato plants no longer showed effects of transplanting. The minus-nitrate plants were about six inches tall, very light green, without buds or blossoms, and many of the lower leaves were yellowed and dropped off: The plus-nitrate plants were about 10 inches in height, vigorous, dark green, and just beginning to show buds at the tips. At 3 P. M. on June 7, 75 of the plus-nitrate

and 75 of the minus-nitrate plants were placed on a wheeled-table and moved from the greenhouse into a dark room immediately adjacent. At 9 o'clock the next morning the plants were returned to the greenhouse. By continuing this procedure the plants received six hours of light exposure daily. These plants will be referred to as the short-day plants. A like number of plus-nitrate and minus-nitrate plants received the full daylight exposure of about 14 hours, within the greenhouse. This group will be referred to as long-day plants.

The dark room was kept at a temperature very closely approximating the temperature of the greenhouse. Ventilation and control of temperature were brought about by means of a ventilation shaft and a 16 inch electric fan.

On July 1, samples of the several lots of plants were taken for analysis. On this same date some of the plus nitrate and minus nitrate long-day plants, were placed under the conditions of the short-day and, likewise, some of the short-day plants were transferred to the conditions of the long-day. After this shifting of some of the plants the experiment was conducted as previously indicated until August 1, at which time all the plants were removed for chemical analysis.

Results on Tomatoes

Short-day, Plus Nitrates. At the end of three weeks the plants were very vegetative, with succulent stems, relatively small, dark green leaves, small blossoms, but no fruit. At the end of seven weeks the plants had not changed in general appearance or manner of growth, except that they were then 3 to 3½ feet in height. Analyses showed that, during the last four weeks, there was a relatively small increase in total amount of nitrogen. Of this increase 50 per cent was of the soluble nitrogen fraction and one-half of this fraction was nitrate nitrogen. In proportion to the carbohydrate content all the nitrogenous constituents were very high, and practically the same at the time of both analyses. The percentage of sugar was very low as was also the percentage of starch and dextrin.

Long-day, Plus Nitrates. At the end of three weeks these plants were growing vigorously and setting fruit abundantly; this same condition prevailed at the termination of the seven weeks period at which time the plants had reached an average height of more than four feet. Comparative analyses showed that during the last four weeks there was a large gain in the total amount of nitrogen; 75 per cent of this gain was of the insoluble fraction. There was a loss in the total amount of nitrates and a small decrease in percentage of nitrates. The percentage of other nitrogenous constituents remained about the same. Proportionally, the plants were relatively low in nitrogenous constituents and high in sugars, with a moderate amount of starch and dextrin.

Long-day to Short-day, Plus Nitrates. After three weeks some of the long-day, plus nitrate plants were transferred to the short-day. Several days after shifting the new stem growth was smaller

in diameter and succulent. Also the area of the foliage was decreased and fruiting ceased although the plants still continued to produce blossoms. Four weeks after shifting to the short-day there was a large increase in total amount of nitrogen, but of this total nitrogen only 50 per cent was insoluble. Nitrates increased very much in total amount as did other forms of soluble nitrogen. The percentage of total nitrogen was more than doubled and the percentage of insoluble nitrogen was greatly increased due to the enormous decrease of sugar and starch. Also there was a large increase in percentage of soluble nitrogen and nitrates.

Short-day to Long-day, Plus Nitrates. Several days after having been transferred to the conditions of the long-day the plants began to set fruit. The stems became less succulent and tender and the new leaves were larger in area. Comparison of analyses of samples taken at the time of shifting and again four weeks later showed that the increase in the total amount of nitrogen was relatively small; of this gain, however, 72 per cent was of the insoluble fraction. There was a loss in the amount of nitrates and due to the very large rise in percentage of sugars and to the slight increase in percentage of starch and dextrin, there consequently resulted a decrease in the percentage of all the nitrogenous constituents.

Short-day, Minus Nitrates. After three weeks the plants were 1½ to 2 feet tall. The stems were slender and succulent, the leaves small and dark green. Small blossoms were abundant but they did not set fruit. Four weeks later the plants had reached a height of 2 to 2½ feet, but otherwise there was no particular change in their appearance or their manner of growth. A comparison of analyses made after three and seven weeks, showed that there was a relatively large increase in amount of total nitrogen during the four weeks period. However, only 75 per cent of this increase was due to insoluble nitrogen. There was a very large decrease in amount and percentage of sugars and starch and dextrin.

Long-day, Minus Nitrates. After three weeks with no nitrates in the nutrient solution, the plants were about one foot tall, and light yellow. Many of the plants had lost their lower leaves and the stems were so hard as to feel woody to the touch. There were no blossoms at any time and at the end of seven weeks they presented about the same appearance as at three weeks. Analyses showed that during the last four weeks there was practically no gain or loss in total amount of nitrogen, but there was a considerable loss in amount of soluble nitrogen and a corresponding increase in amount of insoluble nitrogen. There were no nitrates present at the time of the first analysis nor four weeks later. The percentage of sugars and starch and dextrin was extremely high with a very low percentage of all the nitrogenous constituents.

Long-day to Short-day, Minus Nitrates. In less than a week after shifting new growth commenced on the long-day, minus nitrate plants which were transferred to the short-day. They turned

from light yellow to dark green and after several days produced blossoms, though did not set fruit. After the plants had been transferred for four weeks the second analysis showed an increase in total amount of nitrogen in spite of the fact that no nitrogen had been added to the sand or culture solution in which they were growing. Also there was a gain in the amount of insoluble nitrogen. There were no nitrates present at the time of shifting and none four weeks later. The total amount of other soluble nitrogen decreased. The percentage of nitrogen was very greatly increased due to the enormous loss of starch, but at the time of the second analysis the percentage of sugars had not dropped very low. Proportionally all the nitrogenous constituents were extremely high with a relatively low percentage of sugars and starch and dextrin.

Short-day to Long-day, Minus Nitrates. Several days after having been transferred the plants began to turn yellowish, blossoming ceased, and the stems became hard. In comparing analyses made at the time of shifting and four weeks later, it was found that the total amount of nitrogen increased. There was a complete disappearance of nitrates in the short-day to long-day minus nitrogen plants and a very large increase in the percentage of sugars and starch and dextrin with consequently a decrease in the percentage of all the nitrogenous constituents.

Hemicellulose. The percentage of hemicellulose based on dry weight as determined and under the conditions of this experiment showed practically no fluctuation between the long-day and short-day or between the plus nitrogen and the minus nitrogen tomato plants.

Experimental Data on Other Plants

On February 10, 1922, Silver Hull buckwheat, Wisconsin Early Black soybeans, and Scarlet Turnip White Tip Early radish, were planted in two groups in a greenhouse bench containing rich, sandy loam. At the same time some salvia plants which were about four inches tall and with no external signs of buds or blossoms, were set in the same bench.

Two weeks later, when the seeds had germinated but before the secondary leaves had expanded, a cover which entirely shut out light was put over half of the plants from 4 P. M. until 9 A. M. each day, thereby allowing these short-day plants a light exposure of seven hours. The cover was of tar roofing paper nailed to a light wooden frame and built so that there might be free circulation of air with entire exclusion of light. Daily temperature records were taken in the shelter and outside it. Comparisons showed that the maximum variation which occurred was never more than 2° C. Sometimes the temperature was slightly higher within the shelter, sometimes higher outside it.

The remainer of the plants were given full daylight as it occurred in the greenhouse, and in addition, from sunset until midnight, they were subjected to the rays from a 100 watt tungsten lamp suspended about two feet above the tops of the plants, mak-

ing a total daily light exposure of about 17 hours. This treatment was continued for about eight weeks.

On April 22 all the plants were harvested. The long-day and short-day salvia plants, after having all the soil washed from the roots, were transplanted to 12 inch pots containing quartz sand. After transplanting, half of the long-day and half of the short-day plants were given a nutrient solution containing nitrates; the remaining half of each lot were given a nutrient solution free from nitrates. All the plants were then given the full length of day but without additional illumination. This treatment was continued until May 17, 1922, about three and one-half weeks. During this period a large number of microchemical tests were made.

Results

Salvia. The short-day salvia plants blossomed freely but made much less growth than the long-day plants which did not bloom. From microchemical observations it was found that the short-day salvia plants were relatively high in nitrates, sugars, and starch, but low in insoluble forms of nitrogen. The long-day plants had an abundance of insoluble nitrogen and nitrates, but were relatively low in sugars and starch.

After eight weeks both long-day and short-day salvia plants were given the normal daily light exposure of about 14 hours as it occured in the greenhouse. At this time one-half of the long-day and short-day plants were given a plus nitrate, and the other half a minus nitrate, nutrient solution. The following results were obtained. When given the minus nitrate nutrient solution the short-day plants shed their blossoms, turned yellow and ceased to grow, while the long-day plants blossomed very profusely and continued to grow for 3½ weeks when the experiment was discontinued. The vegetative growth of the short-day plants was very considerably increased when grown in a plus nitrogen culture with 14 hours of daylight. Also there was an increase in the size of the blossoms which were on the plants, but no increase in the number of blossoms. The long-day salvia plants when given a plus nitrate nutrient solution continued to grow very strongly vegetative but failed to blossom.

Three and one-half weeks after transferring to the plus and minus nitrate cultures and to the 14 hour day, the plants were examined microchemically. The short-day minus nitrate plants had lost all their nitrates, they had very little insoluble nitrogen, but did have an enormous amount of sugars and starch. The long-day minus nitrate plants had no nitrates, some insoluble nitrogen, and an abundance of sugars and starch. The long-day plus nitrate plants had some sugars and starch, and an abundance of insoluble nitrogen and nitrates. The long-day minus nitrate plants had no nitrates, some insoluble nitrogen, and an abundance of sugars and starch.

Buckwheat (Silver Hull). The short-day buckwheat plants were very weakly vegetative with dark red stems and greenish yellow leaves at the time of blossoming which was three weeks after the plants came up. Further blossoming did not occur. These

first and only blossoms were few, small and set practically no seed. As the experiment progressed the leaves turned yellow in color except for a little green around the veins. The long-day plants blossomed on the same date as did the short-day plants, but they were dark green, very vigorously vegetative, and continued to blossom and produce seed abundantly until they were discarded five weeks later. At this time they had reached a height of 3½ to 4 feet as compared to the short-day plants which were less than a foot tall. Microchemical observations showed the short-day plants had an abundance of nitrates, some sugar, and were very high in starch, but the supply of insoluble nitrogen was very low and became proportionally less each week with a gradual rise in the proportion and amount of carbohydates. The long-day plants throughout the experiment had an abundance of nitrates, insoluble nitrogen, sugars, and starch.

Soybeans (*Wisconsin Early Black*). The short-day soybean plants were very weakly vegetative, yellow in color, and eight weeks after coming above the ground they were only 4 to 6 inches tall. The long-day plants were very dark green, vigorously vegetative and before this experiment was discontinued grew to be over three feet tall. Neither long nor short-day plants produced blossoms. Microchemical observations showed that the short-day plants had an abundance of nitrates, some sugar, and a very big excess of starch, but that the insoluble nitrogen content was extremely low. The long-day plants had an abundance of insoluble nitrogen and nitrates, but proportionally sugar and starch was very low.

Radish (*Scarlet Turnip White Tip Early*). The long-day radishes were vigorously vegetative with large green leaves and good sized globular roots. The short-day radishes had yellowish green foliage and relatively small leaves, but good sized roots. About six weeks after planting, stems began to develop on the long-day plants and a little later blossoms and seeds. Simultaneously with stem and blossom formation the roots ceased to enlarge further, but became more elongated and less globular. The short-day roots were smaller at first than the long-day roots, but owing to the cessation of root development at the time of blossoming, the short-day roots after a lapse of time became larger than the long-day roots. By means of microchemical examination it was found that the short-day plants were very high in sugars, starch, and nitrates, but low in insoluble nitrogen, while the long-day plants had an abundance of nitrates, insoluble nitrogen, sugars, and starch. The radish stores no starch in the roots and when the long-day plants commenced to produce stems and blossoms the sugar disappeared from the roots. It appeared that in the course of only two or three days there was almost a complete translocation of sugar from the roots of the long-day plants. In case of the short-day plants the roots slowly accumulated sugar and perhaps to a very limited extent insoluble nitrogen with consequently a gradual increase in size of the roots.

Discussion

The preceding results are in harmony with the view that the simpler carbohydrates are used in building up of proteins (insoluble nitrogen fraction, in part) from nitrates. Simultaneously with the decrease in carbohydrates that occurred incident to the shortening of the light exposure, when long-day, plus nitrate plants were transferred from the conditions of the long-day to those of the short-day, there resulted an enormous increase in amount of nitrates and other forms of soluble nitrogen, although there was only a very small increase in the amount of the insoluble nitrogen fraction. Conversely, when a short-day plant was transferred so as to receive a longer light exposure there was an increase of sugars and starch, and accompanying this increase there was also an increase in amount of the insoluble nitrogen fraction and a reduction in the amount of nitrates and other soluble nitrogenous compounds.

In case of the tomato plant, at least within the limits of a 6-hour day, light probably is not a limiting factor in the synthesis of nitrates to insoluble forms of nitrogen provided there is a source of carbohydrates within the plant, although light may increase the rate of synthesis. This statement would seem to be verified by the performance of the long-day minus nitrate plants which were very high in carbohydrates and even after shifting to four weeks of short-day conditions there was a larger percentage of carbohydrates present at the end of this period than in any of the other short-day series. Also, these long-day to short-day tomato plants were the only series of minus nitrate or plus nitrate plants which lost in total amount of soluble nitrogen while under short-day conditions.

The accumulation of soluble nitrogen in the plus-nitrate, short-day plants, possibly was the result, in a large measure at least, of inability on the part of the plants to synthesize nitrates into insoluble forms of nitrogen as rapidly as the nitrates were absorbed by the roots on account of the lack of sufficient carbohydrates. On the other hand, it is difficult to understand what caused the yellow, stunted, minus-nitrate, long-day plants to dark green and grow vigorously when shifted to the short-day conditions, unless there was a decomposition and a re-arrangement of some of the nitrogenous constituents. The chemical data show that the stems of all the short-day, minus-nitrate plants increased in their total amount of nitrogen, while the stems of the long-day, minus-nitrate plants which were not shifted did not gain or lose in total amount of nitrogen. It seems probable that this gain in total amount of nitrogen in the portions of the stems above ground, came from the portions of the plant below the surface of the sand. Although it is possible that it may have been gained through some source outside the plant, this seems unlikely, for the long-day and short-day minus nitrates cultures were identical and the former showed no gain. If the nitrogenous constituents of the long-day minus nitrate roots and stems below ground consisted, as did the stems above ground, almost entirely of insoluble forms of nitrogen,

then before translocation could occur, as it probably did when the plants were shifted to the short-day, there must have been decomposition of insoluble nitrogen in the roots and stems below ground, and a re-assimilation or re-arrangement of such soluble decomposition products, whatever they may have been. This decomposition probably did not result in the formation of nitrates; at least, none were detected in the plants which were transferred from the long-day to the short-day.

Why shortening the length of day should result in decomposition of the insoluble nitrogen fraction can only be inferred from the work of others which it will not be possible to discuss at this time. These changes may be related to the respiratory activities of the plants, since the decomposition of nitrogenous constituents as well as carbohydrate decomposition can occur. Likewise, there seems no reason to believe that synthesis and decomposition of insoluble nitrogenous constituents cannot be taking place at the same time, provided there are some carbohydrates present to combine with the decomposed (soluble) fractions of nitrogen.

This condition may be related to Kraus and Kraybill's[1] high carbohydrate tomato plants which were grown in sand with practically no nitrogen in the nutrient solution. After the tops of these plants were removed the remainder produced new vigorous, succulent shoots, which continued growth in this manner until they became filled with sugars and starch. Also, it is common knowledge that high carbohydrate apple trees respond in a like manner when portions of the tops are removed in the process of pruning.

It will be remembered that the short-day plants without nitrates made a small amount of total growth, yet the type of growth would probably be classed as vigorously vegetative. That is, they were dark green, succulent, and produced blossoms, though no fruit; also the plus-nitrate short-day plants exhibited an identical type of growth, though in the latter case there was about five times the total amount of growth, according to dry weight. However, on the percentage basis of dry matter and moisture, there was not one per cent difference between the two series. The percentage of carbohydrates and insoluble nitrogen was also close. These observations would indicate that it is the proportion of carbohydrates to insoluble nitrogen and not the total amounts of them which determine the type of growth made by plants. While insoluble nitrogen may be the most significant form of nitrogen, there may be certain fractions of the soluble nitrogen which directly affect the responses made by the plant; no specific substances have been determined in this work.

As has been stated, the two series of plants,—short-day minus nitrates and short-day plus nitrates,—were practically the same in proportion of insoluble nitrogen to carbohydrates and exhibited the same type of growth, but in percentage of total nitrogen to carbohydrates there was a big difference between the two groups.

[1]Kraus, E. J. and Kraybill, H. R. Vegetation and Reproduction With Special Reference to the Tomato. Ore. Sta.. Bul. 149 (1918).

This difference was due to the fact that the plus-nitrate short-day plants had a relatively large proportion of nitrates and other forms of soluble nitrogen, which they apparently could not synthesize to insoluble nitrogen, possibly because of an insufficient carbohydrate supply. The short-day minus nitrate plants accumulated only a trace of nitrates as there were no nitrates in there nutrient solution, though they did contain small amounts of other forms of soluble nitrogen.

From these observations, it would appear that the nitrates and probably some other forms of soluble nitrogen in a plant as such, do not directly affect the growth made by it, but simply are stored in the plant until conditions are such that synthesis to insoluble forms of nitrogen may occur; one of these conditions in case of the tomato, as already indicated, is an available suppy of carbohydrates. Also, observations will be cited presently to show that probaby some plants require light of sufficient duration as well as an available supply of carbohydrates for synthesis of nitrates to insoluble forms of nitrogen.

The short-day salvia plants made a moderately strong vegetative growth and blossomed abundantly while the long-day plants made a very strong vegetative growth, but did not blossom. Microchemical observations showed that the short-day plants had an abundance of starch, some sugar, and an abundance of nitrates, but little insoluble nitrogen. The long-day plants had an abundance of insoluble nitrogen and nitrates, but were relatively low in sugars and starch. It would seem that salvia, somewhat unlike tomato, requires a certain duration of light exposure as well as an available supply of carbohydrates for synthesis of nitrates to insoluble forms of nitrogen. Also, it would appear that in this case as in tomatoes, insoluble nitrogen rather than nitrates in proportion to carbohydrates, are directly concerned with the growth response. However, there were no determinations made which would prove that there are not some forms of soluble nitrogen as intimately associated with growth responses as is insoluble nitrogen.

That the long-day salvia needed a larger proportion of carbohydrates to insoluble nitrogen for reproduction, was plainly shown by the marked productiveness which resulted when the proportion of insoluble nitrogen to carbohydrates was decreased. This condition was brought about by cutting off the supply of nitrates, yet simultaneously maintaining an abundant carbohydrate supply. Those plants which still received nitrates in their nutrient solution and in consequence remained high in proportion of insoluble nitrogen to carbohydrates, continued vigorously vegetative and did not bloom. That the short-day salvia plants were low in insoluble nitrogen and could not endure a decrease in proportion of insoluble nitrogen to carbohydrates, was made evident by the termination of blossoming and shortly after of growth when the plants were given a nutrient solution containing no nitrogen, without inhibiting a further increase in the carbohydrate supply. On the other hand, the short-day plants which did not have their supply of nitrogen discontinued, increased in proportion of insoluble ni-

trogen to carbohydrates and in vegetative growth, and retained their blossoms though did not produce more of them. It should be remembered that after varying the nutrient solutions all the salvia plants were given a uniform light exposure of about 14 hours.

Microchemical observations of short-day Silver Hull Buckwheat plants indicated that they were high in nitrates, sugars, and starch, but very low in proportion of insoluble nitrogen. In consequence the plants were weakly vegetative and did not grow more than one foot tall. A few blossoms were formed at the beginning of the experiment before carbohydates had accumulated in very large amounts, but no more blossoms followed and practically no seeds set. The long-day buckwheat plants contained an abundance of nitrates, insoluble nitrogen, sugars, and starch. Therefore, as would be anticipated, they were strongly vegetative and very fruitful.

The short-day Wisconsin Early Black soybeans were weakly vegetative, they did not grow more than 4 to 6 inches tall, and produced no blossoms. Consequently, it was not surprising to find these pants extremely high in carbohydrates and nitrates, but proportionally low in insoluble nitrogen. We have the other extreme of the carbohydrate nitrogen ratio nicely demonstrated by the long-day soybeans which were very high in insoluble nitrogen, but proportionally low in carbohydrates. Nitrates were present in abundance. As a result the growth was very strongly vegetative, but no blossoms were produced during the course of the experiment at the termination of which the plants were 3 to 3½ feet tall.

The short-day radishes of the variety known as Scarlet Turnip White Tip Early behaved in a manner similar to the other plants in this series. They accumulated an abundance of sugar in their roots and starch and sugar in the leaf petioles.. Nitrates were present in abundance, but there was only a very limited amount of insoluble nitrogen present. At no time was there any indication of blossom formation in the short-day plants. The long-day plants contained insoluble nitrogen in abundance, also sugar and starch. Up until blossoming time the long-day plants stored sugar in their roots, after which the sugar supply in the roots became depleted.

SUMMARY

1. Nitrates may be stored by the plant until the proper conditions arise for synthesis to other forms of nitrogen.

2. The presence of nitrates as such in the plant does not appear to affect materially the type of growth of the plant.

3. Conditions resulting in a decrease of insoluble nitrogen and a still greater proportional decrease in carbohydrates resulted in a relatively high proportion of insoluble nitrogen to carbohydrates, producing a strongly vegetative and unfruitful plant.

4. Conditions favoring the formation of an abundance of insoluble nitrogen and simultaneously an abundance of car-

bohydrates resulted in a vigorously vegetative and fruitful plant.

5. Conditions resulting in a decrease of available soluble nitrogen without simultaneously decreasing the carbohydrates supply resulted in a very high proportion of carbohydrates to insoluble nitrogen and produced a weakly vegetative and unfruitful plant.
6. It is inferred conditions resulting in a more or less complete limitation of carbohydrates and a simultaneous decrease in insoluble nitrogen, even though soluble nitrogen may be increased, probably would result in a weakly vegetative and nonfruitful plant. This condition was not found among those prevailing in the experiments discussed.
7. It is possible that certain forms of soluble nitrogen may be as intimately associated with growth responses as are certain insoluble forms of nitrogen; no specific substances have been determined in this work.
8. In the case of tomatoes, light within the limits of a 6 hour day did not appear markedly to limit the synthesis of nitrates to insoluble forms of nitrogen, providing there was present an available supply of carbohydrates.
9. Buckwheat, soybeans, radish, and salvia of the varieties used, however, were limited in the synthesis of nitrates to insoluble forms of nitrogen by a 7-hour day as it occurred in the greenhouse, even though there was present an available supply of carbohydrates.
10. A large decrease of carbohydrates in tomato plants already very high in carbohydrates was apparently coupled with decomposition of insoluble nitrogen when this decrease was brought about by reduction in time of exposure of plants to light. Also, new growth was produced even though there was no external supply of nitrates available to the plant.
11. In the tomato, insoluble nitrogen was not decomposed to nitrates.

The Recovery of Grape Vines when the Young Shoots are Killed by Spring Frosts

By E. ANGELO, *West Virginia University, Morgantown, W. Va.*

WHEN a freeze in early spring kills the bloom on young fruits of the apple, peach or plum, there is no crop that year. In the grape, on the other hand, when the first shoots are killed the second growths are likely to produce a partial crop. It is the purpose of this paper to present the results of a study made last spring on the extent and manner of recovery of certain varieties

when all the first shoots were killed. This past season the spring freezes in this section afforded an excellent opportunity for a study of the recovery of the grape when the first shoots are killed.

The data contained in this paper were taken from vines included in the grape training experiment at the Horticultural Farm, Morgantown. The training block consists of four varieties, Catawba, Concord, Moore Early, and Niagara, trained to the hortizontal arm spur, single stem four-cane Kniffin, fan and high renewal systems. Six vines of each variety were selected for study from each of the training systems. These vines were set in the spring of 1916. On April 21, 1922, the shoots were about 10 inches long with the blossom clusters showing very plainly. The temperature fell to 23° F. during the night of the 21st and was followed by about the same temperature on the night of the 23rd. The first shoots were killed in all varieties under test.

About the middle of May new shoots began to appear and a careful study was made of the recovery of each of the varieties under the different systems of training.

The following table is a summary of the data taken.

A Summary of the Injury and Recovery in Terms of Shoots Killed, the Number and Position of the New Shoots, and the Amount of Fruit Harvested, from Catawba, Concord, Moore Early and Niagara Under Four Systems of Training.

Variety	Average of Shoots Killed per Variety	Number of Buds Growing per Variety after the freeze	Number of Shoots from Buds that produced shoots before freeze	Number of Shoots from Old Wood—Adventitious	Number of Bloom Clusters	Average lot of all Fruit harvested in pounds
Single Stem Four-Cane Kniffin						
Catawba	30.30	22.50	2.80	.00	11.20	.91
Concord	26.30	12.10	.83	1.50	3.80	.53
Moore Early	32.20	10.80	1.20	1.00	3.80	.08
Niagara	24.60	16.00	.66	2.50	9.50	1.20
Average	28.35	15.35	1.37	1.25	7.70	.68
Horizontal Arm Spur						
Catawba	21.10	27.50	0.00	4.00	12.01	1.68
Concord	25.30	25.80	0.00	2.10	10.80	.65
Moore Early	18.00	20.00	0.00	1.00	5.00	.56
Niagara	23.30	20.00	.16	1.60	8.60	1.62
Average	21.90	23.00	.04	2.17	9.10	1.12
Fan System						
Catawba	40.80	22.60	3.10	2.00	10.00	1.03
Concord	30.00	17.00	.50	2.10	2.60	.99
Moore Early	47.00	15.30	.66	.66	5.00	.25
Niagara	26.30	14.60	1.10	2.10	9.30	1.58
Average	36.05	17.37	1.34	1.71	6.72	.78

High Renewal						
Catawba	19.60	13.10	1.80	2.60	6.50	.62
Concord	22.60	10.50	1.00	2.50	44.00	.50
Moore Early	22.40	8.40	.00	.60	2.40	.10
Niagara	19.50	10.80	.66	2.10	3.66	.00
Average	21.02	10.70	.86	1.95	4.40	.30

The first column of figures in the table gives the average number of shoots killed per variety, for the six vines of each variety studied. This number was obtained by counting the withered shoots before they fell from the vines. By comparing these numbers with those in column three it is shown that very few of the buds which sent out shoots before the freeze sent out shoots again. The opinion that following a freeze new shoots come from the same buds that produced shoots before the freeze, is probably true except in such a case of so low a temperature as to completely destroy the buds. It was found in taking the data for column one that in many cases not only the bud was destroyed, but even the wood was killed.

The second column of figures shows the average number of buds growing or producing shoots after the freeze which had not grown before the freeze. The new growths came in practically every case from buds at the base of the canes, or at the base of spurs. These buds would have remained dormant had not the other shoots been killed by the freeze.

As shown by the figures in column two the hortizontal arm spur system produced a much greater number of shoots than did any of the other systems studied. This can probably be explained by the fact that in this type of training there were a greater number of basal buds which remained dormant until after the freeze and then produced shoots. It might be well to state here that the vines were pruned so as to leave about the same number of buds for each system of training.

Column four shows the number of shoots that came from adventitious buds on wood two years old and older,—that is, from wood of the arms or main stem. The number of shoots thus formed is comparatively small, but here again we find a larger number for the horizontal arm spur system than for any other system. None of the shoots of this origin gave rise to blossom clusters.

Column five shows the average number of bloom clusters for each variety under the different systems of training. The horizontal arm spur system again comes to the head of the list with the greatest number of bloom clusters. This is what would be expected since this system gave rise to the greatest number of new shoots. In a normal season Concord has produced on an average of three bloom clusters per shoot. In this case Concord produced 25.80 shoots after the freeze and 10.80 blossom clusters or about 14 per cent of a normal crop of bloom for this number of shoots.

The last column of the table gives the average weight of fruit, in pounds, harvested from six vines of each variety for each system of training. The yield of fruit is much greater in the case of the horizontal arm spur system of training than in any of the others. However, the average yield per vine is much less than the average yield in a normal season. The average yield of 1.12 pounds for the horizontal arm spur system this season as compared to 14 pounds, the average yield in a normal season, shows about 8 per cent of a normal production.

While the data given in the table above cover only one season it is not probable that the response would be much different other years unless the time of the freeze would change. It will be seen that in varieties included in this study there is a fairly consistant type of recovery limited mainly to buds which in all probability would not have produced shoots during a normal season. The extent of the crop from the second growth was quite light, but nevertheless it is quite distinct from the complete failures in many of the other fruits. The type of training had some influence on the number of shoots at the second growth and also upon the yield from them. This did not appear to be sufficiently important, however, to recommend a change in the type of training because the important consideration is the yield during the normal crop years.

Laboratory Tests on Resistance of Apple Tree Roots to Temperature

By G. F. Potter, *Agriculture College, Durham, N. H.*

This paper is to be printed as a bulletin from the New Hampshire Experiment Station.

The Relation of Temperature to Blossoming in the Apple

By F. C. Bradford, *Agricultural College, East Lansing, Mich.*

This address will be printed as Research Bulletin No. 53 of the Missouri Agricultural Experiment Station.

Freezing Injury in the Fruit of the Apple

By D. B. Carrick, *Cornell University, Ithaca, N. Y.*

This paper will be printed as a bulletin by the Cornell Experiment Station.

Carbohydrate Reserves of Young Apple Trees as Influenced by Winter Storage Condition

By P. T. Blood, *New Hampshire State College, Durham, N. H.*

We have for a long time realized that nursery trees should be stored in a cool place. Theoretically, respiration is reduced to a minimum in a cold storage and, therefore, less of the reserve food is used. No literature was found or any evidence of work being done to show what materials are used during the storage period.

This investigation was carried out to determine what carbohydrate reserves were present in the fall and what were lost during storage. Knowing that the tree will be unable to manufacture more food, it must live on what reserve food it has when it enters storage in the fall. It was hoped to find which of the several forms of carbohydrate reserves were drawn on, and to determine the extent of loss, and its relation to growth after planting.

The trees obtained were possibly not of the best type for such a problem. They were 3-year old Gravenstein trees which had been dug to sell as 2-year trees but were replanted in the nursery row. Five trees were taken for analysis before storage, 12 trees taken for each of the two conditions of storage and 12 were fall planted in the field. One lot was stored in a cool, moist cellar in which the temperature ranged between 30° and 40° F. The other was stored in a warmer cellar with lower humidity where the temperature ranged from 45° to 50° F.

In the spring composite samples were taken for analysis from two trees of each treatment, and the other 10 trees planted in the field. When the samples were taken the cool-stored and the fall-planted trees were practically dormant. Those from warm storage had an etiolated growth of from 3 to 4 inches. Separate analyses were made of the branches, trunks and roots. The carbohydrates determined were free reducing sugars, sucrose, starch and acid hydrolizable material. The method of analysis was a combination of the Bertrand and the Munson and Walker methods. The results, calculated as per cent of dextrose in the green weight, are presented in Table I.

TABLE I

Reserves of Nursery Apple Trees; Carbohydrates Expressed as Per Cent of Dextrose in Green Weight.

	Fall analysis (before storage).	Cool cellar Storage (30°-40° F.)	Warm cellar Storage (45°-50° F.)	Fall Planted
BRANCHES				
Reducing Sugars	1.45	1.78	1.37	1.63
Sucrose	.57	.00	.00	.20
Starch	1.33	.75	.34	.55
Acid Hydrolizable Material	10.70	11.06	10.11	11.35
Total Carbohydrates	14.05	13.59	11.82	13.73
Total Carbohydrates Exclusive of Acid Hydrolizable Material	3.35	2.53	1.61	2.38
TRUNK				
Reducing Sugars	1.11	1.10	.95	1.21
Sucrose	.36	.03	.00	.00
Starch	1.30	.64	.39	.56
Acid Hydrolizable Material	11.47	11.27	10.61	12.14
Total Carbohydrates	14.24	13.04	11.95	13.91
Total Carbohydrates Exclusive of Acid Hydrolizable Material	2.77	1.77	1.34	1.77
ROOT				
Reducing Sugars	.85	1.03	.88	1.40
Sucrose	.54	.35	.35	.57
Starch	4.00	3.50	2.30	3.14
Acid Hydrolizable Material	10.24	11.09	8.24	8.21
Total Carbohydrates	15.63	15.97	11.77	13.33
Total Carbohydrates Exclusive of Acid Hydrolizable Material	5.39	4.88	3.53	5.11

Considering first the fall analyses, it may be noted that the total carbohydrates, including the acid hydrolizable material, are nearly equal in trunk, branches and roots. However, the different carbohydrates are not so nearly equal. The reducing sugar is about 25 per cent less in the root than in trunk and branches, while there is about three times as much starch in the roots as in the trunk and branches.

The most striking point noted in the spring analyses is the absence of sucrose in the branches and trunk of trees in each condition of storage. In the roots the amount of sucrose is relatively the same after storage as before.

The total carbohydrates, excusive of acid hydrolizable material, show drops under all conditions of storage. This would be expected, since as mentioned above, there was no chance for

the trees to manufacture carbohydrates so the food material used in respiration must come from storage material. Starch showed a marked decrease in every part of the tree and under each storage condition. The loss of starch was much greater under warm storage than either of the other cooler conditions. Starch loss in warm storage amounted to 75 per cent in branch, 70 per cent in trunk and 43 per cent in roots, as compared with amounts before storage. Since the per cent of loss of starch in the roots is great, and since the roots are a relatively large part by weight of a young tree, the loss of starch in the roots is probably an important one.

The percentages of acid hydrolizable material vary to some extent, but are properly within the accuracy of the determination, excepting in the case of the warm storage and planted out trees, which show a loss of about 20 per cent in the roots. It would be expected that if this material could be used in roots it would also be used in the trunk and branches. However, the difference may be due to the fact that the chemical composition of the roots is much different from that of the rest of the tree. The acid hydrolizable material of the roots may be composed of different substances and may be in more available forms of food in the root than in the tops.

This investigation shows that there is considerable loss under conditions that apparently keep the trees in a dormant condition. The ideal storage would be a condition that will not only keep the trees apparently dormant, but also keep them from respiring and using storage food materials.

Observations on Some of the Newer Spraying Materials

By C. H. GOULD, *Agricultural College, Amherst, Mass.*

DURING the past season there have been advanced by manufacturers and laboratories, several new spray materials, supposed to be improvements upon standard brands. Many of these compounds are purely experimental while a few are recklessly advertized as "cure-alls" with apparently very thin evidence to substantiate the claims made for them.

A few of these have been tested out in a small way at the Massachusetts Agricultural College with the idea of measuring so far as possible: 1 Foliage injury: 2 Injury of the fruit: 3 Their insecticidal or fungicidal value as compared with standard formulae. The materials reported on here include Sulfurex, Sulco V. B., NuRex Spray Dried, NuRexo and Celesto.

In applying these sprays the directions of the manufacturers were followed to the letter, and applied at the highest concentrations recommended. They were applied to a number of varieties,

the most important of which from the standpoint of the Massachusetts grower, are Baldwin, McIntosh and Wealthy. These varieties were also of value because they exhibit varying degrees of susceptibility to spray injury, Baldwin and Wealthy being quite susceptible, and McIntosh quite resistant. References made to the behavior of these materials will be in terms of their reaction on these three varieties. The standard sprays with which they are compared are reputable brands of liquid and dry lime sulphur.

One or two new ideas in spray material manufacture were exhibited in two products of the Mellon Institute, namely Sulfurex and Celesto.

Sulfurex is a hard, yellow rock-like substance, quite hygroscopic, with a strong oder of CS_2, and completely soluble in water, producing a clear yellow liquid.

Considerable may be said in favor of this material as regards its mechanical condition. It is compact and concentrated, thereby helping to reduce transportation charges and storage space. It is easily and comfortably handled, and the fact that it dissolves completely would seem to free it from one of the chief faults of dry lime sulphur, and in its compactness and ease in handling it seems to outrank the liquid lime sulphur, which is so often criticized because of its bulk. If a product of this type could be developed which could be safely used, it ought to have a considerable range of usefulness.

But the results of its applications are not as encouraging. The maker gave no statement of its analysis, but our Station chemist reported it to contain polysulphides of potassium, and it is quite evident that some CS_2 is present. When applied as a summer spray diluted 2 pounds to 50 gallons of water, it burned foliage severly on Baldwin and Wealthy, yet did not injure McIntosh. It russetted the fruit on Baldwin and McIntosh, but did not seem to russet Wealthy. Its behavior seems to indicate that this type of material is worth experimenting with further, provided it can be made so that it is safe to use.

Celesto, according to the manufacturer is an ammoniacal copper carbonate. It is a dark blue powder with a wicked aroma of ammonia.

The makers, at the time the sample was submitted, were of the opinion that Celesto was a "fungicide much less harmful to foliage than bordeaux; that it would control fungi when in full evolution, under which conditions bordeaux is of little value." It was further believed that because it "contained no sulphates it might be used where bordeaux might be harmful." Our Station analysis shows evidence of carbonic, sulfuric and hydrochloric acid in the compound.

Our tests were not made with the idea of proving or disproving these ideas, but to gauge the safety of its application, and in this respect the results are negative, nearly one-fourth of the foliage being stippled to a greater or less degree, and about one-third of the crop badly russetted.

The Toledo Rex Spray Company has produced a dry lime

sulphur compound called Nu Rex Spray Dried, which seems to compare favorably with recognized brands of dry lime sulphur.

This is a lemon yellow powder, fine and soft textured, which dissolves quite well in water leaving a relatively small amount of sediment, and that so finely divided that it is forced through the nozzle leaving little sediment in the tank.

This product appears as safe to use as other forms of dry lime sulphur, comparing favorably with them chemically and physically, yet apparently possessing no real superiority.

Another product of the same company is called Nu Rexo, a Bordeaux lead compound, in the form of a bluish powder, which handles easily and mixes well giving a spray of the same general appearance as bordeaux. This spray spotted the foliage about as much as a 3-10-50 bordeaux, and russetted the fruit a great deal worse, averaging 71 per cent of crop badly russetted as against 51 per cent for the regular bordeaux arsenate lead mixture. This injury to the fruit was so great that even though it might be used with safety on the foliage, it would be poor practice to sacrifice much fruit that would otherwise be perfect. It was generally true that all bordeaux combinations tried injured the fruit so badly that their general use is of doubtful value.

Sulco V. B. is manufactured by Cook Swan & Company, but advertized most extensively by a Virginia orchard firm. The advertizing matter describing this product is both entertaining and confusing.

In general the product is a dark, heavy mobile liquid, with a combined order of fish oil and carbolic acid. However, samples submitted during the last three years have never been the same, chemically or physically, and the directions for use have varied from year to year.

Its effect on foliage has been disastrous to say the least, and its use should be discouraged until it can first be consistently prepared and guaranteed.

In general it may be observed that these new materials are not as reliable as our standard formulæ of liquid lime sulphur and lead, and need further investigations before they can be offered to the orchardists of the state as safe and effective sprays.

The Summer Practicum

BY S. W. FLETCHER, *Pennsylvania State College, State College, Pa.*

TWENTY-FIVE years ago instruction in horticulture at the Land Grant Colleges was chiefly, if not wholly, by means of lectures. Many a graduate in horticulture has entered the professional or commercial field with little or no preparation from contact with soil and plant. This has long been one of the disadvantages of college instruction in horticulture as compared with instruction in other branches of agriculture, especially animal husbandry and

dairying. Interest in practicum instruction has developed rapidly during the past 10 years. In that period, the number of practicum hours in proportion to the number of lecture hours, has almost doubled. Few courses are now given in which the number of practicum hours is not at least equal to the number of lecture hours. The trend of the times in horticultural pedagogy is distinctly toward a larger proportion of the art with the science.

The main purpose of practicum instruction is not to enable the students to acquire skill in handicraft. That is the function of a trade school, not of a college. A certain amount of familiarity with commercial practice is indispensible, but no college should undertake to provide all the practice that is needed to make a successful gardener, florist or fruit grower. The major portion of this training must always be derived from the school of experience. The goal of the college practicum is not so much to train the hand as to stimulate the interest. Few students acquire from a text-book that love for their work, which is the basis of success. Enthusiasm for horticulture is developed only by contact with plants. A class in pomology will show much more interest in the class-room instruction after a three-day trip through commercial orchards. Enthusiasm is the spark that fires the charge. If it is lacking, no amount of class-room instruction will fill the student with horticultural zeal.

In recent years, from one-third to one-half of the students in horticulture have come from cities, having had little or no experience with plants. This has accentuated the need for the college practicum. Several practicum methods are used at different colleges, aside from the almost universal two to four hour practicum associated with certain courses. One method is to ask all students to meet certain farm practice requirements either before entrance, or at some time before graduation. This may be one year of work on a farm, or only a summer. This method is logical, in that it recognizes the principle that the college is not the place to learn the details of commercial practice. But it is often unsatisfactory, in that the college does not supervise the work, or have any check on it. The point of view of the farmer in employing a student is to put him at work where he can be used to best advantage, whether this gives a variety of work or not. He wants a laborer, not an apprentice. The point of view of the student, on the other hand, is to participate in all the operations of the farm and to learn all he can; he is willing to labor provided he has a chance to learn. Some of my students who have taken their summer practicum in commercial orchards have spent nearly the entire summer digging out borers. They returned to college without any great accession of interest in horticulture. Undoubtedly we must continue to rely mainly on extramural experience to give our students the spark of enthusiasm, yet there is need, also, for the college-supervised summer practicum.

At the Pennsylvania State College the summer practicum was first offered about 12 years ago as a six weeks' inspection trip required of all students. This served a useful purpose especially

in broadening their outlook, but was open to two grave objections —the heavy expense, and the fact that the students did not do any work themselves but merely saw it done, which is quite different. Then followed a few years when students were placed on farms, supposedly of the most progressive growers, during the summer between the junior and senior years. They were furnished an outline of what to observe and required to make a full report on the organization of the enterprise and on the details of its management.

This plan was about 30 per cent successful; that is to say, about a third of the students returned to college with a livelier interest in horticulture and with an experience in commercial practice that they felt was really worth while. Many of the others had their enthusiasm dampened rather than quickened. In some cases, of course, the students themselves were wholly at fault, and the growers dismissed them, as they would any other lazy or incompetent help. The summer practicum on the farm of a progressive grower, who will take a personal interest in students who are willing to work hard, is the very best kind of a practicum, especially when the students have had some previous experience, but the percentage of successes is too small to make this method useful with classes of 20 to 25, such as we are dealing with at the Pennsylvania State College.

We have now come to the summer practicum at the college. The Pennsylvania State College is rather remote from commercial horticultural establishments, but is fairly well equipped for practicum purposes, the Department of Horticulture having about two hundred acres of land, including sixty acres of orchards and small fruits. Last summer the juniors were kept at the college in two groups, each group remaining six weeks; next summer we shall have a single practicum of eight weeks, which will be coincident with the Summer Session of the college.

The students lived in town and were paid a wage barely sufficient to cover the cost of room and board. Next year we propose to build a camp for the pomology and vegetable gardening students on the farm, which is one and a half miles from the town, and to board them there. We want them to live in the orchards and gardens for eight weeks and to forget the co-eds and dances, for the time being. They put in an eight or nine hour day. An instructor is with them all the time, not only to direct the work, but also to answer questions. At the beginning of the practicum each student elects to take it in the orchards, or in the gardens, or in the greenhouses. A schedule of operations is arranged so as to cover all the details of practice that are seasonable, and some that are not, interspersed with studies that are purely academic. In pomology, for example, each student cultivates the orchard with the tractor, runs the sprayer, thins, picks, and packs the fruit, and does other work that is timely. Among other things he is expected to learn the lesson of work, which is a wholly unexplored field to some students. One hour each day is devoted to class-room discussion, usually on subjects that are engaging

the attention of the students in the field on that day. The literature of the subject is placed before them and considerable reference reading required, especially on stormy days. The culmination of the course is a seven to ten day inspection trip through important commercial establishments of Pennsylvania and neighboring states. The student is required to keep a diary of observations on his work and on the trip.

It seems to us quite imperative that the summer practicum be given as a course of instruction, like any other college course, not merely as labor. The instructor should be with the students at all times, mainly to call their attention to interesting points. The academic standing of the practicum is further emphasized by the daily conference hour, by constant reference to the literature of the subject, and by giving grades on the course. We are not excusing any student from the summer practicum because of previous experience. Our aim is to make it so varied and interesting that every student will profit by it, even those who come to us with considerable practical experience. Eventually we hope to keep the students for the summer practicum between the sophomore and junior years and help them secure work on commercial enterprises the following summer.

The summer practicum at the college is not practicable at all colleges. It would be better, in some cases, to conduct it away from the college, on private farms, but under strict college supervision. Our experience indicates that the summer practicum will become as indispensable to the curriculum in horticulture as has the summer camp to the curriculum in forestry. It should be emphasized at the close of this report, as at its beginning, that the main purpose of the summer practicum is to stimulate interest, not to provide commercial practice; and that it should be given as a regular course of instruction, not merely as supervised labor.

The Teaching of Orchard Practices in Pomology Courses

By F. C. Sears, *Agricultural College, Amherst, Mass.*

I DO not believe it is possible to teach orchard practices effectively and satisfactorily without a judicious admixture of laboratory and lecture work. And by a judicious admixture I should mean a fairly liberal amount of laboratory work. In our courses at the Massachusetts Agricultural College, the usual proportion of lectures to laboratory work is two one-hour lecture periods to each two-hour laboratory period. And in practice this seems to work out fairly well. Of course the amount of laboratory work which is desirable will vary considerably with the subject under discussion. Some subjects like pruning require a maximum amount of such work, while others, like seeding down an orchard to a cover crop, can be fairly successfully taught with very little. But laboratory

work we must have if the student is to get the most out of the course.

Since most instructors are fairly well committed to the lecture, or text book side of such courses, (and I shall not raise the question of the comparative value of lecture and text book), I shall devote the short time at my disposal largely to a consideration of the laboratory end of the combination.

There are in my opinion, three requisites to successful laboratory work in the type of courses now under consideration. *First* we must give the *right kind of work.* And on this phase of the question the most resourceful instructor in the world may use all his powers and not overdo it. We must use the *very best methods;* we must have *thoroughly up-to-date equipment;* and we must attempt, just as far a spossible, to *synchronize* our laboratory and lecture work! It is useless to attempt to interest our students in old, worn out, discarded methods and practices. If the job is packing apples in boxes, one must have modern presses and packing tables, and not the top of a barrel for a table and a fence rail for a press. If the exercise is pruning apple trees the student must be given a modern, sharp swivel saw to work with and not an old, dull carpenter's saw. And we must make sure that the particular method which we teach is the best one, or, if there are two equally good, then both should at least be discussed, even though it may seem desirable to concentrate our practice on one of them.

The point of synchronizing the lecture and laboratory work is a difficult one to live up to, and we never can attain perfection there owing to our dependence on weather conditions. But most of us might do much better in this respect than we do, and it is certainly much more effective to have the lectures and laboratory work on pruning apple trees come in the same week, rather than to have them separated by a month or two.

In the second place, there ought to be an abundance of laboratory work available. The student who prunes one grape vine on the high-renewal system is better off than the fellow who doesn't get into the vineyard at all, or the one who merely sees a demonstration. But what the man ought to have is a whole row to prune. He then gets an idea of the system; he sees that every vine is a different problem, and he has some notion of how grapes differ from apples or raspberries, in their method of fruit bearing and the method of pruning.

In the third place, we must have the right attitude on the part of the student towards the work. Usually we do get this attitude if we have been careful about the first consideration of giving the right kind of work. But, however we get it, we simply must have it, and the instructor who attempts to conduct such a laboratory exercise as we are considering while his students are in an indifferent or inattentive frame of mind, might better dismiss them and go and play poker.

One of the greatest points in making laboratory work interesting to the student is, I believe, to give him just as much insight as possible into the scientific principles involved and to have him

understand just as fully as possible why the work is done as it is. If it is a question of pruning a grape vine then he ought first to study what happened to the vine last year, how it was pruned and where it bore its fruit. Next, he ought to discover where it will bear this year and in how many different ways that particular vine might be pruned and still keep to the method of training involved. And by this time he is ready to begin to prune it intelligently and to get some real enjoyment out of it. Or if he is pruning mature apple trees there is an endless amount of interest to be derived from studying what the tree did last year and year before, what it will do this year; what difference there is between a McIntosh and a Baldwin and a Wealthy tree in all of these respects and many others.

In order to carry out such laboratory courses most successfully, many details must be worked out in advance of each exercise and preferably a long time in advance. Of course these details will vary greatly, but the following are some of the points which I have found important and which apply to almost any line of such work.

1. Each student should have a definite assignment of work for which he is responsible; for example, a certain row of grape vines or a certain number of apple trees to prune. Where the responsibility is *not* localized it is impossible to place the credit for either the good or the poor pruning.

2. There should always be an outline or syllabus given to the student before each exercise to direct him in his work. This outline may take various forms but should preferably be of such a character as to raise questions in the student's mind which he can satisfy by studying the work in hand.

3. An account of every laboratory exercise should be written up by the student and it should be a full account written in a "readable," interesting way.

4. Following each laboratory period the instructor should conduct a quiz, either written or oral, on the work of that period.

5. There should be special tools, such as pruning saws and shears, for each student and if possible, no other student should use them. Frequently this is not possible, but it is desirable.

6. Students should be encouraged to equip themselves with comfortable and appropriate clothes for this outdoor work, and wherever possible should be given individual lockers to keep them in. They should also be warned at the beginning of the term that they will frequently be called upon to go out into the fruit plantations for laboratory work when it would be more comfortable to sit down in the lecture room.

7. A full list of the laboratory exercises for each course should be worked out in advance of the course and immediately after each exercise has been given the instructor should sit down and consider how it might be improved for the next year. And of course from year to year some exercises will be abandoned and new ones substituted.

And lastly may I suggest, that in my opinion, such courses, if properly handled, may possess just as much "cultural value" as a course in English or Latin or economics or history. Our brother instructors in these other lines are inclined to consider that while technical courses may have to be admitted to the curriculum for the sake of their "practical" value they have absolutely no real educational or cultural value. A student *ought* to get as much mental stimulus out of studying the past history of an apple orchard, what it did and why it did it, as he will out of speculating on the probably history of the Zulus of South Africa, or the food habits of the ichthyosaurus. If he doesn't there is something wrong with the course in pomology, or with its instructor.

Teaching Horticultural Manufactures

By W. W. Chenoweth, *Massachusetts Agricultural College, Amherst, Mass.*

THE teaching of horticultural manufactures in our agricultural colleges needs no justification. It is as much a legitimate part in the solution of the nation's food problems as are many of the courses found in our curricula and far more important than some of them.

It is true that many of our universities and colleges maintain courses in home economics or domestic science in some of which food preservation is studied. The work in such courses, however, is aimed primarily to satisfy the needs of the home-maker and must not be confused with work that would be given in courses in horticultural manufactures which have for one of their major objectives at least the teaching of methods for the preservation of food in quantities for market. Besides men will not, as a rule, enroll in domestic science courses while they will freely elect courses in horticultural manufactures.

Courses in horticultural manufactures offer to the departments of pomology and market gardening opportunities to give to their students a more complete course of instruction than would otherwise be possible. And while most of students in such courses will be drawn from the above named departments, experience has shown that students from other departments as home economics, agricultural economics, agricultural education and animal husbandry will freely elect if opportunity is given.

Students enterng courses in horticultural manufactures should be well trained in bacteriology, chemistry, physics and agricultural economics. This preliminary training is essential to a full appreciation of the principles involved in the preservation of food and its successful marketing.

Just how much work can profitably be given depends largely upon local conditions, and local conditions must in a very large

measure determine the amount and character. It is my judgment, however, that students should start with their junior year and the course should be a continuous one extending throughout the year in order to cover the widest possible range of raw materials. This arrangement would permit students to specialize, or to take advanced courses during the senior year. This general course should approximate ten credits.

The work should be largely laboratory. At least two-thirds of the credits offered should be worked out in the laboratory. Lectures or class periods are necessary for the presentation of a certain amount of general knowledge which shall guide the students' activities in the laboratory and library. The class period may also serve as a sort of clearing house where the whole class may assemble to check up results, and to clear away any misinterpretations of results and to unify and correlate the work of the course.

The content of all courses will be governed in general by the objectives. This is particularly true with respect to the laboratory exercises. Any specialization, however, might well come in the senior year leaving the course of the junior year to deal with general principles only. If this assumption is true, then the content of the junior course should include the general principles relating to our common methods of food preservation, with at least a bit of history connected with the development and growth of this industry in its many branches. This would include the general subjects of canning, evaporating, storage, salting, use and abuse of preservatives, synthetic foods and the manufacturing processes of many kinds of fruit and vegetables products such as butters, conserves, jams, jellies, marmalades preserves, pickles, relishes, etc. Students should be taught the characteristics of each class of fruit and vegetable products, so that upon examination of any particular product they could place it in its proper class. They should also know the characteristics of high grade products and should be given a number of exercises in judging and classifying. Their instruction would also include those methods of manipulation of raw materials which will produce high grade fruit and vegetable products.

Economy in time, energy and materials, high quality and uniform grade of products, should be the guiding principles of all laboratory work.

Advanced or special courses will deal with some one or more, or with a group of closely related problems having their foundation in the general course, or they may be aimed at efficiency in workmanship in order to equip students for particular jobs.

It does not require a large amount of expensive equipment in order to give good laboratory courses which will teach the students the general principles and practices of food preservation. In fact it is better for the student if much of his equipment is relatively small and simple, because then much of the work may be assigned as individual problems. A student will get more from a laboratory exercise in which he must perform the entire operation than if he does only one or two steps of it or if he is merely a spectator. He not only fixes in his mind the entire operation,

when he does the work himself, but he is at the same time acquiring some skill in the manipulation of equipment and materials.

In addition to the simple desk equipment of kettles, pans, spoons, measuring cups, thermometers, hydrometers, colanders, etc., there must be some general laboratory equipment such as scales, fruit presses, cider mill, food choppers, steamers, steam pressure cookers, water baths, and other miscellaneous pieces of kitchen and small factory equipment. If space and funds permit the installation of types of commercial equipment best suited to the industry of the state would be of great value to the students.

If, however, commercial methods of food preservation form the main objective the laboratory must be equipped to teach those methods. This would mean larger and more expensive equipment, at least approximating that found in the commercial factory. It would mean also that the method of instruction must be changed. Instead of individuals being responsible for the work it would be done by groups or as piece work.

I still believe, however, that the general course should precede specialization and factory methods, or that factory methods be given along with the laboratory exercises in the general course.

The actual teaching of courses in horticultural manufactures presents many problems that do not arise in most college courses. In the first place the materials for such courses have not been organized and the instructor will find an almost entire lack of precedent to guide him in his selection. The bulk of available literature is more or less questionable, or is not applicable to the needs of the instructor. The raw materials which must be used are as a rule highly perishable and must be handled when in condition. Consequently the instructor finds he must rely almost entirely upon his own ingenuity to construct well balanced correlated courses, and that he must adapt himself to the conditions which are imposed upon him by his environment.

Most of our college courses are so organized that the instructor may start the student at the beginning and gradually step by step unfold the entire subject in a logical and commonly accepted pedagogical manner. This is not so, however, when teaching horticultural manufactures. The student may find himself at the very beginning of his course plunged headlong without any preparation into a laboratory exercise involving work in canning, the manufacture of fruit juice, jelly, butter, pickles, relishes, etc. Such a system of instruction must appear hopelessly chaotic to the profound systematist, or to the deeply scientific or mathematically trained mind. But what are we to do? Are we to teach each of the subdivisions of our subject matter as an integral whole? If we do we shall shortly be without materials for our laboratory work. The time to teach the canning of grapes is when one has grapes. That is also the time to teach how to make grape juice, grape jelly, grape relish, grape butter, etc. Other fruits and many of the vegetables must be handled in much the same way. And what must appear still more illogical to the casual observer, is the fact that in order to carry out certain phases of the course the laboratory work must shuttle back and forth using fruits to-day,

vegetables to-morrow, and perhaps fruits again the day following. But this is absolutely necessary if the instructor is to utilize to best advantage all the rescources at his command. The laboratory course must be sufficiently elastic to permit of these sudden and frequent changes and the instructor must be agile enough in mind and enthusiastic enough to carry his classes from subject to subject without loss of interest and without the student losing the relationships of the laboratory work to the big problem of food preservation.

I have yet to be shown that such a system of instruction where the student is continually going back and repeating the same or similar operation with a different material is not a more effective method of instruction than to approach the subject by subdivisions mastering each before advancing to the next one.

The instructor in horticultural manufactures also finds that unlike his brother teacher of chemistry, physics, and other sciences, he does not have a close relation in point of time between lecture and laboratory work. As a matter of fact his students may be doing work at the beginning of their laboratory course which will not come up in lectures before the very close of the course, and vice versa. And while this somewhat chaotic condition must exist if general principles are being taught, the average student will come out at the close of the term with a well balanced knowledge of the subject matter of the course if the instructor will but do his part in organizing and correlating the lectures, and the library assignments.

He who plans a course for another to teach assumes a grave responsibility. Particularly is this true where the course must be a flexible one and where the sources of information are widely scattered and unorganized. Therefore, the following very brief outline for a course in general horticultural manufactures is offered merely as a suggestion in the hope that at least some part of it may be of use to anyone contemplating organizing college work in this subject.

1. *Fall Term.* Five credits, two lectures and three 2-hour labratory exercises per week.

    A. *Lectures*:

    1. Importance of food preservation and its relation to the agriculture of the state and nation.
    2. General principles underlying the manufacturing of fruit and vegetable products.
    3. Classification of fruit and vegetable products together with standards for each class.
    4. The cider apple and its economic use.
    5. The canning of fruits and vegetables.

    B. *Laboratory work.*

    1. The canning of pears, plums, apples, quinces, peaches, and grapes, and the manufacturing from them of their various products with special study of methods of jelly making. Emphasis is placed

on the utilization of cider apples through pasteurized cider, apple butter, vinegar, and other cider products.

2. The canning and otherwise preserving and storing of the late summer and autumn vegetables, with some time given to vegetable products.
3. The manufacture of mince meat.

Note. Emphasize the fact that in most cases quality of raw material is the important thing; that raw materials may, and in many cases should be, the low market grade or culls.

II. *Winter Term.* Three credits, one lecture and two two-hour laboratory periods.

A. *Lectures.*

1. The evaporation of fruits and vegetables.
2. Storage construction and operation of storages.
3. The pure food law.
4. The use of adulterants and preservatives.
5. Synthetic foods and drinks, their food values as compared to real products, etc.
6. The farm factory.

B. *Laboratory work.*

1. The utilization of small fruits, special attention given to blends or combinations in the making of jams and jellies, the use of apple as a base and particularly emphasizing the place of the apple thinnings in extending and improving the flavor and quality of small fruit products.
2. Studies on relative values of varieties of small fruits for canning and manufacturing purposes.
3. Evaporation of fruits and vegetables.
4. Fruit candies such as candied fruits, pulled candies, soft candies, dipped candies, pastes, etc.
5. Citrus marmalades.

III. *Third term.* Two credits, two two-hour laboratory periods.

A. All necessary lecture work to be given during the laboratory sessions.

B. Laboratory work.

1. Continuation of same type of work as in winter term i. e. special products as pickles, relishes, etc.
2. Utilization of early vegetables.
3. Maple products.
4. Inspection trips to nearby factories and other food preservation plants.
5. Plans and drawing of small factories with studies of equipment for same.

6. Or the entire time may be spent in studying the food preservation problems connected with the type of work carried on in the state.

Long Time Demonstration Work in Pomology

By R. A. Van Meter, *Agricultural College, Amherst, Mass.*

When extension work was still younger than it is today, when objectives were obscure, methods bungling, and farmers shy, it was quite the fashion to spend our time upon the easier and more spectacular operations which are concerned in orchard management. We often overpruned trees, for we were obsessed with the idea that we must teach farmers to prune, and pruning a tree meant only the amputation of something, rather than leaving the tree in the proper condition for fruit production. Our spraying work was largely confined to the methods of applying spray materials. We often tried to teach farmers to spray well with inferior equipment, when what they really needed was crops which would pay the overhead on sprayers which would spray. In short, our efforts were directed superficially toward an improvement in the technique of a few operations. These were outstanding needs and we did some good work, but we had not yet grasped the real problem with which we were, and are, confronted. We left the farmer to work out the big things.

Today, I take it, every state orchard program has for its ultimate goal better fruit, more fruit per acre, and lower cost of production. These things can be influenced but little until we strike into the heart of the operations which influence fruit production, and concern ourselves primarily with the fundamental operations of soil management, pruning and spraying, not as unrelated exhibitions of the skillful manipulation of tools, but as interlocking factors involving a multitude of processes quite inseparable in their many ramifications, some of which are obscure while others possibly are entirley unknown.

Proper soil management is probably of first importance, at least in point of time, for other efforts are largely wasted if the trees are starving. We extension men have been most negligent in this regard. Pruning is closely correlated with the nutritional problem, for together they probably determine the set of fruit. Spraying, the protection of the crop, must wait upon the others, for we must first get a crop worth spraying and trees which are not too dense to be sprayed effectively. Neither soil management, nor pruning, nor spraying, will stand alone. How, then, can they be demonstrated separately?

Again, no orchard demonstration is completed until it can be translated into fruit production. The combined results of proper soil management, pruning, and spraying, cannot be measured in one year, or in two, but are cumulative over a long period.

Only by repeated blows at the same spot can we drive home the real value of good management. That is the purpose of the economic management demonstration.

Organization

The first demonstration orchards in Massachusetts were planted in 1910. Professor Sears was responsible for the project. The county agent system was not established and the orchards were directly connected with the Extension Service at the College. The College furnished the nursery stock and the spray outfit, and in return the farmer contracted to follow directions for 15 years, and to report at the end of each year the expenses incurred and all returns from the orchard area. We now have twelve of these orchards as strategic points in the state.

The project as first organized was sound and effective as far as it went. It was open to the objection common to all demonstration work done by the college specialists; that is, the amount of work, the number of demonstration orchards in the state and the attention given to each, were limited by the available time of one man. Since the completion of the county agent organization, the immediate supervision of the orchards has, in the main, been gradually turned over to the county agents. We find that twelve county agents, properly directed can do better work than one specialist.

Conduct

In the spring pruning season the county agent and the specialist go to the orchard and block out the program for the season. Pruning is started, and spraying and soil management are given special attention, but all other operations are taken into consideration. Some time during the summer the specialist drops around again with the county agent to see that everything is in a satisfactory condition. The county agent makes it his business to keep in constant touch with the cooperator, visiting the orchard frequently and giving direct, personal assistance in solving the problems which come up. When necessary, the specialist is called upon for added assistance. The county agent and the specialist work together to see that the orchard is an example of good orchard management. No expense is spared to secure the best results, and neither is an expense advised unless it will result in a worthwhile improvement.

Utilization

The safest and soundest kind of stimulus to further planting in any section is a well-managed and profitable orchard. It can neither be hidden away nor can it overemphasize the importance of orcharding in that vicinity. Cooperators have been impressed with the idea that a part of their job is to answer questions on the management of their orchard. Not one of the 12 cooperators was a good fruit man at the start, but they have invariably grown with the orchards, and the men who have orchards in bearing can give sound and sensible advice on most practical orchard problems. They have had the advantage of learning right the first time.

These men have been supplied with literature for distribution and they have gradually come to be known as dependable advisors. Some of them are regular speakers at grange meetings and other gatherings.

No cooperator has ever been urged to advise neighbors who are perfectly satisfied with their methods. In the first place, the neighbors, being Yankee farmers, will rarely tolerate such interference. In my experience few farmers, anywhere, will submit to that sort of thing and we do not care to have as a representative a man who is considered a nuisance in the neighborhood. In the second place, if our methods of managing orchards do not, over a period of years, prove clearly better than those practiced in that neighborhood, we probably have no better system to introduce and do not deserve consideration. There remains the occasional man who will not adopt a new practice, even if it is clearly demonstrated to be better. His case is hopeless, anyway.

The county agents have found the management demonstrations valuable and useful. Prospective planters, as well as fruit growers in trouble, are urged to visit and examine the orchards. About 1000 people visit them each year, and 150 fruit growers are following them regularly. Each year at pruning time we hold a field meeting in each orchard to discuss the program for the season. About half the orchards are visited each year by groups of farmers on fruit tours, for thinning demonstrations, or upon similar occasions. Cost accounts have been kept on each of these orchards and these valuable data are now in process of arrangement for publication.

Another Plan

Nearly every neighborhood in Massachusetts is now producing fruit in some quantity. The few orchards started by the College were not numerous enough to reach all neighborhoods where instruction in fundamental principles was needed, and after a few years' experience, seven of the 11 county agents, with the help of the specialist, began to extend the system by establishing similar management demonstrations under their direction. There are now about 50 such orchards and others are added from time to time as conditions seem to warrant it. In these orchards the cooperator furnishes all the materials and agrees to follow directions, to allow his orchard to be used for frequent field meetings, and to pass on to interested farmers the information which he receives. There is no long-term written contract, and there is no time limit; the Extension Service is free to withdraw at any time if the demonstrator fails to give satisfactory cooperation; the orchard owner may discontinue the use of his orchard as a demonstration whenever he feels that he is being asked to do something unsound, or is being neglected. This tends to keep us all working. Several orchards taken over under this plan have been released, but none, so far as I know, at the request of the orchard owners.

The plan seems to work well. The orchards do not have as wide an influence as those more intimately connected with the

Agricultural College in the mind of the farmer, but it is possible to supervise a great many more demonstrations. It is also comparatively easy to change demonstrators, and that is sometimes highly desirable. The big advantage of the contract system is that the cooperator signs an agreement to do a definite thing. He is sure to understand his job. One county is experimenting successfully with contracts which run for one year only. In others we are using written instructions, and I think that this will prove satisfactory. Misunderstandings in such cases are generally the fault of the extension people and can seldom be charged against the farmers.

Troubles

The greatest factor for success with a long time demonstration is the right cooperator. It took us years to learn that if the demonstration is to be most effective, the demonstrator must belong to the group which we are trying to reach with the demonstration. A good demonstration orchard on the farm of a wealthy man is of little value to neighboring farmers. They will never believe, cost accounts notwithstanding, that the man is not spending a fortune to keep his orchard in good condition. On the other hand, the demonstrator must be able to buy equipment and supplies without embarrassment, or he may be unable at a critical time to carry out instructions and the orchard will suffer. The cooperator must also be a man in good standing in the community. Local politicians are often eager to serve as demonstrators, but on the whole they are a poor lot. Their motives are not the right ones. Neighborhood quarrels have also prevented the effective utilization of several excellent management demonstrations. Under the old contract system it was rather difficult to withdraw from such a situation, but with no contract or with a succession of annual contracts, this problem is comparatively simple.

Another thing which has reduced the efficiency of many demonstrations is the common tendency of county agents and all the rest of us, especially the rest of us, to plan more work than we can supervise to the best advantage. In a general tightening up on the whole project we have in the last two years discontinued a number of the demonstrations which were least effective. The amount of personal attention required has been reduced by using the mails freely, but at best the project necessitates careful supervision, especially in the earlier years when the cooperator is being trained to think along the right lines. By the time the orchard has produced a few real crops, he has a good grasp of the essentials.

In speaking only of the economic management demonstration I do not mean to suggest that all our efforts should be turned in this direction. This is the most difficult kind of demonstration to handle effectively. Some groups of growers have a good working knowledge of the fundamental principles underlying orchard management and are ready for the finer points in the art of growing good fruit. The latest development in pruning, spraying, thin-

ning, or fertilizing may be taught to such men more quickly and efficiently by lectures, or by demonstrations of technique, such as pruning a tree, or mixing bordeaux. They may be lax only in the use of fertilizers or in the proper time for applying the pre-blossom sprays for apple scab, and shorter, more highly specialized demonstrations, preferably of a comparative nature, will take care of such problems. But for the broad foundation work in fruit growing, I do not believe that anything will entirely replace the long time economic management demonstration, and we still have in most states many fruit growers in the kindergarten class.

Strawberry Club Work in Illinois

By W. S. Brock, *University of Illinois, Urbana, Ill.*

THE following project was started as a means of producing some fruit on that great area of central and northern Illinois known generally as the Corn Belt. As the thing advanced, however, it became quite as popular in other sections, a condition which was quite acceptable, although rather unexpected.

The situation in the Corn Belt of Illinois with reference to the old fruit garden is just about as bad as it could be. The farm orchards planted 20 to 30 years ago grew rapidly (too rapidly in fact), but produced quantities of fruit until by multiplication of pests the trees became a liability, especially as the land upon which they were planted grew more and more valuable. Few farmers had the time or inclination to take up with modern methods of disease and insect control. One other factor has played an important part in the disappearance of the farm orchard in the Corn Belt. The tenant problem which is perhaps more acute in Illinois than in any other state, has resulted in from 40 to 60 per cent of the land owners living in the towns or cities adjacent to their farm properties. With 40 to 60 per cent of the land being farmed by tenants under the usual Corn Belt farming principles, it is easy to see that however much (or little) the owners might be interested in taking care of the trees the tenant was interested not at all; or if the tenant should by any chance wish to take care of the fruit trees, in nearly all cases the owner was unwilling to allow him sufficient remuneration for his time or effort. It seemed, therefore, that anything which could be done to reduce the amount of canned fruit which the farmer buys annually and thereby increase the amount of fresh fruit used, would be a worthy undertaking. As a matter of fact, the average Corn Belt farmer, either tenant or owner, uses mighty little fruit in any form. In searching about for something which would produce a maximum of fruit with a minimum of effort, the strawberry was decided upon as the most cosmopolitan of all fruit and, therefore, likely to yield the best results.

The work of our extension activities through the medium of a central office at the Agricultural College and the County Farm Bureaus as manned by a farm adviser, or an adviser and one or more assistants, is a splendid organization through which to work, providing the details can be reduced to a minimum, or where the machinery once set in motion can be fed by publicity and information from the central office. It was known at the outset that the plan must be made "fool proof" so far as the adviser was concerned, because in each case he has already more work than he can attend to.

It was decided that all the plants which were to be grown under this project should be of one variety namely, Senator Dunlap, and that so far as possible all of them should come from one grower for the sake of cheapness and uniformity. Accordingly, arrangements were made with the W. W. Thomas Co. of Anna, Illinois to furnish the plants for this project on the following prices:—

$ .60	per	100
1.10	per	200
1.75	per	500
3.50	per	1000

Another thing, and this is important, the plant company agreed at this figure to send the plants by parcel post in individual packages direct to the club members. This much having been agreed upon, the publicity was put out through the regular channels, being careful not to give too many details in the first article. Through the news service and farm bureau news letters, which eventually got into the local papers, within six or seven weeks everybody in the state who could read was informed that a strawberry club project was contemplated, and for further information was advised to write to the Specialist in Boys and Girls Club work, or to the Department of Horticulture at Urbana. Form letters were prepared to answer such inquiries stating the essential features back of the movement and suggesting that those interested send their names direct to one of the two addresses above mentioned, stating the number of plants desired; it was further stated that the letter must be accompanied with the cash. The results were beyond our wildest expectations, considering that all we expected to do this first season was to find out the flaws in the program and perfect it so that the 1923 campaign would be on a sound basis.

The number of individuals responding during the season of 1922 was 739 distributed over 78 of the 104 counties in the state. These ordered 228,900 plants or an average of 300 per person.

As soon as the orders were received each member was expected, if he or she had not already done so, to communicate with the farm adviser, or the club adviser in the county in which the boy or girl lived, and receive the instructions, or be instructed, in the matter of procedure. The adviser, or county club leader, was supplied with the club manual which was simply a circular setting forth the fundamental principles of strawberry culture and written especially for this project. The club member agreed to

follow the directions as outlined and among other things, agreed to keep a record of the yield and report to the central office direct, or through the adviser at the end of the fruiting season.

Unfortunately, the season was unfavorable for the growing of strawberry plants. The mortality was unusually high although the figures at this time are not available on this point. Excessive rain fall in the early spring followed by the opposite extreme made the growing of plants unusually difficult even for an experienced person. From time to time each member was mailed direct from the club leader's office at the University, timely hints on what to do and when to do it in order to combat these adverse conditions. This is one of the essential features in the success of the campaign. If it were necessary to depend on the farm adviser or his assistant to see that this was done, in most cases other things would interfere and the information would not be given out.

It is admitted that this account is purely of a preliminary nature and should not have been given at this time or place, because the success of the undertaking will depend upon fruit produced and not plants sold or set in the ground. However, the inquiries which have come in seem to make it desirable to give this much information at the present time as a progress report.

Fruit Demonstration Work in Kansas*

By L. C. Williams, *Agricultural College, Manhattan, Kansas.*

1. General Outline of Year's Work December 1, 1921, to December 1, 1922, as Planned.

The work for the year was outlined in accordance with the plans drawn for sub-project No. 9 (the horticultural project). A copy of this project as submitted to the county agents follows:

The Extension Specialist Will:	*Date of Work.*
1. Meet county organization project committee with county agent and develop plans for conducting this project in the county.	December, January.
2. Hold extension schools in orcharding, and conduct pruning demonstrations and tours. At these demonstrations and schools the cooperators for the ensuing year will be selected. (This will include pruning acre-orchards also).	December, January, February.
3. Accompany the county agents in locating additional cooperators not reached by demonstrations.	February and March

*Mr. Williams would have presented this subject in this form had he been present at the meeting. This is a unique presentation and ought to be of value to other extension men (Secretary).

4.	Furnish the county agents information in regard to reliable sources from which to secure nursery stock, spray materials and spray machinery.	March and April.
5.	Conduct orchard planting and spraying demonstrations.	March and April.
6.	Furnish county agents with up-to-date orcharding information.	During entire year.
7.	Conduct spraying demonstrations in cooperators' orchards.	April, May June.
8.	Send out timely topics, report blanks, etc., to orchard mailing list.	April, May, June, July, August, September.

The County Agent Will:

1.	Arrange meeting with county project committee.	December and January.
2.	Arrange extension schools or demonstration meetings.	December, January, February.
3.	Locate desirable cooperators.	December, January.
4.	Make arrangements with cooperators for the purchase of trees, spray materials and necessary machinery.	February.
5.	Arrange schedule of demonstrations in cooperators' orchards.	March, April, May, June.
6.	Insist upon cooperators keeping records and broadcasting spray dates and other timely information to the men in their communities interested in the same project.	April, May, June, July, August, September.
7.	Publish results.	

The Project Leader Will:

1.	Assist in securing cooperators.	December and February.
2.	Assist in arranging and advertising all meetings.	December and August.
3.	Assist in obtaining records.	August and September.
4.	Turn these records over to the county agents.	September.
5.	Determine the acreage cared for according to recommendations, the number of trees planted, the amount of spray material used, and secure other	September and October.

information of use in advancing the project.

The Local Cooperator Will:

1. Hold demonstration meetings. As requested.
2. Secure equipment necessary.
3. Help advertise all meetings.
4. Keep records and furnish county agent with copies.
5. Exhibit samples of fruit if requested.

2. General Conditions Affecting the Work.

The extension work in horticulture is organized at the present time in such a manner that the specialist devotes the major portion of his time to orchard management and general fruit production. There is undoubtedly as great an opportunity for effective demonstrations in truck crop production, but so far most of that work has been developed by the extension plant pathologist, with the horticulturist giving what assistance he could.

There are several reasons for this division of labor, among which are:

a. The requests for fruit work alone are more than one specialist can handle.

b. The specific problems in truck growing are for the most part of a pathological nature, such as potato seed treatment rather than problems of soil fertility or cultural methods.

c. There are now 100 one acre orchard demonstrations in the state which demand seasonal attention, making it necessary to employ a temporary assistant for two or three months during the year on that work alone.

d. With the beginning of this season, two years had elapsed since a creditable fruit crop had been produced in Kansas, and a state-wide orchard clean-up campaign was necessary.

3. Special Features of the Project Work.

The special features of the year's work are here listed chronologically:

a. Six extension schools and orchard tours combined were held in counties where orcharding was a major project. There was a total of 19 sessions at these schools with an attendance of 462. These schools were held with the assistance of Prof. Albert Dickens of the horticultural department, E. A. Stokdyk, extension plant pathologist, and E. B. Wells, extension soils specialist.

b. A four-day short course in horticulture was held in connection with the Farm and Home Week program at the college in February. Fruit and truck problems were discussed and demonstrations given. The attendance at the short course was 100.

c. A spraying campaign was inaugurated with approximately 60 cooperators, all of whom were to apply at least four sprays according to the schedule best suited to their needs. Some of the principal demonstrations with the number of cooperators in each were:

1. The use of lime sulfur in controlling cherry leaf spot	2
2. The use of bordeaux in controlling blotch	8
3. Pruning and spraying vs. neglect	40
4. Efficacy of general spray schedule in controlling codling moth vs. spraying on dates determined from codling moth traps	6

d. Codling moth traps were placed in a number of prominent orchards in the Arkansas Valley and two weeks were spent in determining the emergence of the second brood of worms.

e. An orchard tour was held in cooperation with the Sumner and Sedgwick county farm bureaus and the Arkansas Valley Fruit Growers' association. Twelve orchards were visited with an attendance of 625. A community supper at Oxford and a community dinner at Belle Plaine, were features of this tour.

f. The college fair exhibit was prepared and shown at three state fairs. In this exhibit were a 150 foot city lot built to scale (4 x 12 feet) and landscaped according to the latest improved methods, pictures and drawings showing landscaping methods, and enlarged photographs of scenes taken in the college orchard illustrating the value of cover crops. A total of 247,000 persons saw this exhibit.

4. Examples of Individual Work.

The specialists in soils and horticulture assisted Harry E. Baird, county agent of Ford County, in organizing the Ford County Potato Growers' Association. The association began work with 11 members and now has 30. During the year it handled $16,000 worth of potatoes, all grown under irrigation. The organization also held an educational campaign featuring potato seed treatment and soil fertility tests.

Mr. S. Hahn of Coffeyville, one of our best cooperators for the past two years, says in part in his report for this year:

> "My neighbors never get done praising the good results derived from spraying. Apples, peaches, plums, grapes, berries and pears were clean of scab, blotch and worms.
>
> "We used in our spraying work this year 500 pounds of lead arsenate, 1,000 pounds of lime, 100 gallons of scalecide, 200 gallons of sulfocide, 50 pounds of dry lime sulphur and 500 pounds of tobacco stems."

Mr. Hahn sprayed for some of his neighbors after caring for his own 50-acre planting of young trees. There were about eight members of the spray ring. He owns the sprayer (a Giant

Friend) and charges $1.25 an hour, the owner furnishing the material and hauling the water.

Ed Houser is the owner of a home orchard at Nashville, and has been a cooperator for two years. The first year his crop was killed by frost. This season he harvested 932 bushels of apples from 122 trees, for which he received $732.00. His actual expenses were about $150.00. This is a good example of the profitableness of orcharding as a sideline.

STATISTICAL SUMMARY OF SPECIALISTS' WORK

Days in field	161		
Days in office	139	(of which 42 were spent in work on state fair exhibit)	
Days on vacation	12		
First class letters written	641		
Circular letters written	4	Circulation	1,200
Timely Topics	8	Circulation	24,000
Newspaper articles	19		
Bulletins and circulars mailed	5000		

MEETINGS

Demonstrations	*Number*	*Attendance*
Pruning	55	922
Spraying	20	148
Acre-orchard demonstrations	26	90
Other orchard demonstrations	14	130
Truck crop demonstrations	4	70
Fair exhibits	3	259,000
Tours	4	898
Demonstrations at high schools	4	52
Extension schools	10	568
Institutes	1	20
Other meetings	6	372
Farm visits	245	327

Cooperators located ....69 (In addition to 100 acre-orchard cooperators).

Annual reports received:

Orchardists	72	
Truck growers	2	
Associations	2	(One fruit and one potato growers' association).

Partial reports from orchardists received to date list 9,101 apple trees as having been sprayed according to plans suggested by the extension horticulturist. The harvest from these trees was 36,223 bushels of apples. This is exclusive of the acre-orchards and the young commercial orchards not yet in bearing.

Reports from county agents and fruit growers' associations and from dealers in spray materials indicate that in the orchard spraying work over the state, chemicals were used as follows:

Lead arsenate	64,025 pounds
Copper sulphate	10,950 pounds
Lime sulphur	44,010 gallons

In addition to the work done by the regular extension horticulturist, Mr. A. A. Glenn was employed from March 1 to May 31 to assist in acre orchard work. The following statistics are taken from his report:

Total number of meetings held	52
Total attendance	622
Average number in attendance	12
Total number of general meetings attended	6
Total attendance	217
Average attendance	36
Total number of farms visited	60

The following statistics are taken from the annual reports of county agents and indicate the activities in their counties:

Farms on which orchards were planted (apple, peach, pear, etc.	336
Acres involved in the above	680
Farms on which fruit trees were pruned	636
Acres involved in above	3,637
Farms on which bush fruits were planted or farm practices relative to bush-fruit culture improved	131
Number of acres involved in above	202
Acre-orchard projects in counties	99
Orchard cooperators who followed definite schedule of sprays	266
Men reached through these cooperators	1,151
Pounds lead arsenate used in spraying fruit trees	26,707
Barrels lime sulphur used in spraying fruit trees	971
Pounds bordeaux mixture used in spraying fruit trees	6,675

Development of Fruit Demonstration Work

By C. P. Close, *United States Department of Agriculture, Washington, D. C.*

Introduction

IN considering the lines of fruit demonstration work to be attacked in any state, one should decide upon the most important needs of the fruit industry and then hit those needs hard while still following a well balanced program. If the trees and plants need feeding more than anything else then widespread fertilizer demonstrations should be started to cover as many fruit sections as possible and make the project so big that the whole state will take notice. The point is to do the very important things in a great big way and get somewhere with them and forget the little

things and the personal service once so popular. An example in mind is the fruit fertilizer work in Michigan where tree fruits and bush fruits in many counties throughout the state are used in one big plant feeding project. This is worth thousands of dollars to Michigan fruit growers now and will increase in value several fold in the next few years. Other examples are tree pruning in Oregon where 75 per cent of the fruit growers in the principal fruit sections have adopted the extension system taught, and in Washington where orchard cover and shade crops receive state wide attention.

Cooperation with Business Interests

There is a wide field of service for the fruit specialist in bringing the fruit grower and business interests together as has been done in one instance in Missouri in inducing druggists to carry stocks of spray materials at reasonable prices. Contacts should be formed with manufacturers or dealers in all kinds of spraying materials, spraying equipment, fertilizers, orchard machinery, barrels, and any other necessary supplies. The business interests must be shown the purpose of supplies, the amounts needed, the time when needed, and be given the assurance that such supplies will be purchased. Ready to serve brands, as of spray mixtures for instance, are desirable for many people who will not do the things it takes time or skill to perform. Druggists might be given circulars of information on fruit and garden diseases and insects and methods of control. Sources of cover crop seeds, fertilizers, barrels, crates, etc., might be located and price quotations obtained. This of course would be done in cooperation with county agents who would attend to the details within the counties, but would not become financial agents.

Lines of General Work

Of all the general lines of work that of tree pruning is undoubtedly the most popular. In tree pruning the trend is toward less cutting of branches, consistent with good shape of top. Pruning schools and pruning tours are most serviceable in this work. A pruning project should be continued at least three, or better five, years on the same trees. The high renewal system of fruit tree pruning now popular on the Pacific Coast is worthy of careful study and trial throughout the country. The use of fertilizers and cover crops is increasing and in the Pacific Northwest cover crops are almost spectacular in their beneficial results in orchards. Spraying is still the limiting factor in good fruit production throughout the country. The various lines of orchard soil management are as important as ever. The work with small fruits and grapes might well be increased several fold. As a sidelight on fruit demonstration work it may be mentioned that in the Southern States last year under the direction of the home demonstration agents, there were 9394 women doing orchard demonsration work and 9186 doing demonstration work with small fruits and grapes. This work consisted largely of planting, pruning and spraying. This would indicate that it might be practicable to start orchard work with women in the other states.

Spray Rings

The spray ring is the salvation of many of the home and farm orchards and is working successfully in several states. Iowa is still away in the lead with 654 spray rings in operation this year according to reports of the county agents. Of these 213 used power sprayers and 441 used barrel pumps. It would be well for other states to organize spray rings as fast as possible not only to save farm orchards, but also to develop the spirit of cooperation among farmers. It is a real pleasure to visit members of spray rings and hear their words of praise over the results obtained. By training the county agents and a few leaders the work may be largely turned over to them, but the state specialist should make a visit or two each year to give advice as needed and to keep the project moving.

A distinction has been made between the home apple orchard and the farm apple orchard, the former being only large enough to furnish fruit for the family and the latter being semi-commercial in size. I believe the real home orchard is what we should work for with only enough summer and fall varieties for seasoned needs, thus having the bulk of the crop of winter varieties. Ten or twelve bearing trees would meet this need. One difficulty last summer and fall in the spray ring work was the production of a heavy crop of summer and fall apples for which there was no sale. The weather was hot, the fall and late summer varieties ripened in a bunch and the market became glutted and continued so for several weeks. It will be highly desirable, if not absolutely necessary, to organise each spray ring having farm orchards into a packing and selling group to handle the surplus crop. This would make a good starting point for cooperative marketing.

Cooperative Packing and Selling

As fruit growing becomes more highly developed, cooperative packing and selling becomes a desirable necessity. This idea was well worked out in New York recently and has given excellent satisfaction. Ohio organized several local associations this year and is pleased with results. In sections away from good local markets the association way is one of the best means of putting honestly packed fruits on the market and association organization ought to be taken up by other states.

Cooperation in Local Fruit Sales

There is a big opportunity in helping to sell the farm orchard crop either at the farm or in the local market, and a project of this kind is worth while. Advertising by local paper, handbills, or road signs, will direct the consumers' attention to the point of supply. Recipes on the preparation of fruits for serving will be helpful. The local merchants should be induced to handle good fruit only and at reasonable prices in convenient packages. Fresh supplies should be brought in only as fast as they can be sold. Assistance should be given the merchants in advertising by variety names and special uses of the different varieties. In some instances it would be practicable to rent a storeroom and sell fruit in any

quantity as is being done with citrus fruits at the present time. Special ads will bring flocks of purchases to these salesrooms.

Cooperation with Nutrition Specialists

A big and useful field for fruit and vegetables specialists is opening up in connection with the work of extension specialists in nutrition who are attacking the food problems of farm and village people. These specialists know much about the nutritive value and digestive possibilities of fruits and vegetables, and can recommend such combinations in the diet as to not only assist very materially in preserving good healt, but also to repair certain ills brought about by improper diets. There are many cases of sluggish livers, faulty starch digestion, high blood pressure, and even diabetes, which are benefitted by the proper use of fruits, or vegetables or both. In a number of states nutrition specialists are definitely recommending the use of at least one fruit and one vegetable, but preferably two fruits and two vegetables, besides Irish or sweet potatoes, in the daily diet. Food selection demonstrators are being enrolled to undertake to provide this amount of vegetables for their families. The food preservation project is being preached as a systematic method of estimating the amount of fruits and vegetables that must be stored or canned to meet these needs of the individual family during non-producing months.

The vegetable specialists might well cooperate in planning the garden giving a list of crops for spring, summer, fall and winter use, the space and amount of seed and fertilizer or manure required for each, the time and method of planting, the care of crops with respect to cultivation and pest control, the best maturity condition for gathering, use and storage of crops, the best varieties especially adapted for home canning, and making of storage pits and building storage cellars.

There is really a vital need in the human system for more of the salad plants and greens, and a good many of these are now available for practically the whole growing season and several may be taken from the late fall garden and stored for early winter use. The humble cabbage, carrot, and rutabaga have now advanced to the vitamine class, and the lowly tomato ranks with the Sunkist orange and lemon in antiscorbutic value. Rhubarb may be made an all-year crop by having a few extra plants for winter forcing. These are a few suggestions for the vegetable specialist. The nutrition specialists might well revise an old familiar slogan to read, "Two vegetables a day will keep the doctor away".

The fruit specialist can cooperate by advising the kinds, varieties and number of plants of small fruits and grapes for the fruit garden, and the way to plant, prune, cultivate, train, and care for them. The fruit garden is one of the most important items connected with the home. Tree fruits might or might not be included in the project.

As a people we are all remiss, some very much more so than others, in good healthy home living. There are not enough farm and village homes with well balanced fruit and vegetable meals, and it is a part of our job as extension specialists to help create

the desire and demonstrate the way to grow better things for the home. I do not mean that we should "live to eat" but rather that we should "eat more intelligently to live better and longer." Most farming people spend more than 300 days and eat a thousand meals at home each year. During the last two or three years comparatively few farmers have made more than a living, and many have only existed and have lost their farms and homes. If their living is their most certain reward, why not have this reward as happy and satisfying as it can be made? A little more time, thought, and work with fruits and vegetables, will help toward better living and this amount of time and effort taken from producing unprofitable crops will be a blessing. But "here's the rub," and I know it as well as anyone, how can the average farmer or laborer be conjured into the mental attitude of desiring a better and saner living? I do not know, but I *think* that it will be done by the nutrition specialists and home demonstration agents working with the farm women, the junior canning clubs, the schools furnishing hot school lunches, and in general educational work along these lines.

The cooperative gardens as developed in Europe are worthy of serious study for use especially in our cities. These are really permanent small fruit and vegetable gardens grouped together usually on rented ground. They were first used in Denmark in 1883 and soon thereafter spread to Norway, Sweden, Finland, Holland, England, France and Germany. These gardens have resulted in better and happier living, improved health, and the saving of more money by the people having them. As early as 1820 the group city gardens were developed in Germany under the name of Scherbergartens.

Better Homes

As extension work develops it gets nearer and nearer the farm and village homes and we must make good in reaching and improving these homes as well as in helping to increase the annual income. Our part is to improve the outdoor homes, that is, the lawns, the flower beds, the shrubbery beds, the shade trees, the walks, etc. If the farm men cannot be interested in this subject through the county agents, the farm women can be interested through the home demonstration agents. Perhaps the first step will be to teach the county agents and home demonstration agents enough of the fundamentals to arouse action toward a small beginning.

The idea of home demonstration agents doing yard improvement is new in the Northern and Western States, but has been used successfully in the Southern States since 1919 where there are now 117 demonstrations under way. Only one county agent in the South is doing this kind of work; he has four yard demonstrations.

It would seem well to start some of this work in a small way in a few of the counties of each state. If an influential farm or village woman would make a start in the way of cleaning up the yard, seeding the lawn, mending the fence, or planting a few

flowers or shrubs or shade trees, and would associate two or three of her friends with her into a landscape ring, each doing something in the way of yard improvement, a real start would be made. A striking example of getting something started is that of the home demonstration agent of Hamilton County, Tennessee, who induced 110 farm women to have some improvement made on the foundation of their houses, such as building a lattice or wall, planting vines, flowers or shrubs, or making some other foundation improvement. A humble beginning like this will lead to great results as the southern figures show. Here are a few of the 1921 results for reflection:—fences repaired around home, 6925; unsightly buildings repaired or removed, 3484; lawns seeded, 1955; people who planted trees, 8208; people who planted shrubs, 11,276; people who planted flowers and vines, 42,396; number of trees and shrubs planted, 53,090. It seems rather astounding that such results are obtained the third year after the project began.

Junior Club Work

One of our greatest opportunities to do constructive work of lasting fame is with the boys and girls. Of the 11,000,000 farm boys and girls in the United States, only 600,000 are now in club work of any kind. By cooperating with the junior club departments we ought to be able to get 25,000 boys and girls started in fruit club work in 1923. The club departments should do the organizing and direct the seasonal operations through county agents, home demonstrative agents and local leaders. The state fruit specialist should furnish subject matter and timely suggestions and give such personal attention to the subject as time permits.

As a rule juniors do not care to wait long for financial returns so the strawberry is the most promising fruit for club work. To prove the possibilities of this line of effort we need only refer to the splendid work done by Illinois last spring in organizing 736 boys and girls into strawberry clubs planting nearly a quarter of a million plants. This is easily the most outstanding piece of small fruit extension work in 1922 and might well be emulated in other states. The goal set by Illinois in this project for 1923 is one million plants. In the Southern States in 1921 there were 1472 club girls demonstrating strawberry growing. One girl in South Carolina made $165.25 from one-eleventh acre of strawberries, this is at the rate of $1817.75 per acre. In one county the club girls planted 8800 strawberry plants last year.

The blackberry, dewberry, raspberry and grape are longer time propositions than strawberries, but there is a place for them in the North as well as in the South where about 4000 club girls are demonstrating how to grow them.

Orchard club work should be very greatly increased. Indiana has the apple club work well established in the county agricultural high schools with the Smith-Hughes vocational teachers as club leaders. There are now 31 of these leaders. The work is handled in two ways, by class clubs, using an orchard for each club, and by other clubs using the home orchards individually. There are

18 class clubs using orchards containing 1180 trees. All of the members of each club share in the work of the club orchard. In the other clubs each member does his work on a few trees in the home orchard. There are 89 boys doing this home club work on 2880 trees.

In York County, South Carolina club members planted 3701 apple, pear, quince, peach, plum, cherry, fig and pecan trees, and 240 grapevines last year. In the Southern States 3266 club girls were demonstrating orchard work in 1921. Nine hundred twenty-three girls worked with apples, 1669 with peaches, 632 with pears, 256 with citrus and 642 with nut trees. The girls using more than one kind of fruit are counted more than once in the last sentence, but not in the total number, 3266.

The junior garden club work should be kept going at full speed. In 1921 the southern club girls grew and sold nearly $120,000.00 worth of vegetables besides providing $216,000.00 worth for home use. An off-shoot of garden work is club work with flowers. Last year in the South there were 10,344 club girls demonstrating the growing of flowers. Near cities this project can be made quite profitable by growing the kinds in demand as cut flowers.

Another subject of considerable importance, though not always of club calibre, is that of making collections of native nuts to include in club exhibits at county, state and other fairs, and to search out the very best native black walnut, butternut, pecan, hickory nut, hazel or other nuts in any section. The fair authorities ought to be induced to offer prizes for collections of native nuts as well as for the best sample of each kind. This is being done at a few fairs and some of the state club people are taking considerable interest in the subject. We need most of all a large native hazel of thin shell and good quality. Trust the boys of any community to know where the best wild nuts grow.

Conclusion

This address is not intended to discuss all of the points connected with fruit and related demonstration work, but rather to direct attention to some of the outstanding things being done and to others which would be worth while doing. The richest field of all to enter is that of the 10,400,000 farm boys and girls who are strangers to any kind of club work. There must be many among them who would fit perfectly into a fruit club project. Closer cooperation with home demonstration agents and nutrition specialists in the making of better homes and better living is essential. Cooperation with business interests is necessary. The tackling of the vital problems in a big way is fundamental. We have the background of good work well done and the bright future of bigger things yet to be accomplished.

The Relation of Extension and Research Work in Vegetable Gardening

By H. F. Tompson, *Massachusetts Agricultural College, Amherst, Mass.*

EXTENSION workers in vegetable gardening are a product of very recent years. For several years these extension men have had to orient themselves to find out what they could do, and determine how to do it. There has been great joy in the heart of many a conscientious worker when problems of the farm have been discovered on which the investigation of the research worker would shed light, and where he could be the live wire which would connect the dynamo with the incandescent bulb and make light where there had been darkness.

The search, by college trained specialists, of solutions for the problems of the farm, has been a thoroughly sympathetic one, and productive of much good. It has vitalized every branch of professional agricultural endeavor. The work has consisted of:—(1) A recognition of the lack of needed progress; (2) A careful study to determine the specific causes of prevailing conditions; (3) The application of "remedies" already at hand; (4) The stimulation of research, and assistance in directing the search for answers to unsolved problems.

I believe that agricultural extension work has been, and will continue to be, one of the most fundamental branches of the service of our whole scheme of agricultural education, for education it is, carried to the men on the farm. The extension worker must be a man who adds to the efficiency of the producer with whom he works. He must be able to answer, or find the answer to mooted questions which constantly arise. He must do more than that. He must stir up questions often accepted as settled, and stimulate thought on problems considered solved, where experience, trained judgment and investigation, have proved that common practice is less profitable than new or unaccepted methods. The extension specialist, through the county farm bureaus must stimulate a feeling of hopefulness where discontent has prevailed, and this can only come through better performance. He must himself be a believer in what he does.

The "tools" of his profession are;—(1) His own love for and belief in agriculture; (2) His professional experience and training; (3) His ability to work with men; (4) His knowledge of the experience of farmers and of the fundamentals of success; (5) His ability to keep in close touch with and influence proper research.

Extension specialists in vegetable gardening, are, for the most part, state extension specialists or county specialists where the interests of the county call for that type of specialization. Their work must be to assist the development of the commercial vegetable

growers' business along sound and economic lines. Campaigns, or projects, must be founded on the right principles, well determined facts, or established and successful practices.

In the most advanced communities, where the business of commercial vegetable gardening is active and prosperous, the specialist frequently comes up against problems for which he can find no adequate solution. These often are of long standing. Frequently some research man has recognized the particular problem. Often he has indicated the need for investigation, and frequently outlined the work, and there it has stopped. The extension specialist often feels discontent over this situation and he has had it augmented through the further knowledge that when some research worker has had a chance to make his investigation, frequently his research has stopped short of the goal, and added nothing to the economic efficiency of agriculture, or increased the ability of the extension worker to render service.

Happily, these experiences are now resulting in a get-together of extension service men, with experiment station investigators. This is a great help to both. This friendly study together is most essential to the best progress. The extension specialist has a greater opportunity for popular service than does the research man. He may be compared, quite fairly, with the man of the business house who goes out to meet the world and sell goods, while his partner stays at the factory and produces the article of merit which makes it possible for the man on the road to sell, with pleasure and profit. There must be team work and service production, to make the business succeed. So it is with the extension worker and research man. In many instances our experiment station and research work in vegetable gardening had reached a stage of neglect, even dry rot, in some cases, which augured ill for the future, until the development of extension work revived it through the direct connection with the business men of the industry.

To-day the extension specialist is discovering unsolved problems at an alarming rate. He is also proving that problems considered solved require further study. His is the duty to prove this need. Naturally the investigator has to be shown the further need of investigation, and when shown, he must be given time to organize his forces and get his work under way. The extension specialist until he thinks the situation through, is very likely to become impatient with the progress of the research man for it is far easier to ask questions than to answer them, as Mr. Edison knows. It seems to me that it is too often true that our research workers underestimate the importance of the economic problem as compared with so-called "pure research" from which no *immediate* economic gain is in sight. My own feeling is that the pressing economic problems should have the right of way, for it comes back to our great big problem, the business success of agriculture, and its relation to the success of our nation.

Rarely does the successful research man prove to be the best extension worker. The reverse is equally true. Each needs some personal qualifications which particularly fit him for his type of

work. The research man needs to be a thorough student and to be able to concentrate on the particular problem on hand. He needs to have a sustained interest, and a thirst for knowledge which leads him on and on. The extension specialist must know his subject matter, have a deep interest in his work, and have a working knowledge and enthusiasm which he can impart to his constituents.

Some illustrations of cooperation between extension and research men may be pertinent to the question. It is best for me to draw upon experiences in Massachusetts. Our county agents found the pasture problem a big one in the dairy sections of the state. Unproductive pastures and low milk production had been big factors in increasing the cost of milk. As a result of this "discovery" our experiment station has recently reorganized this as a research problem, and in addition to the extension demonstrations founded on general knowledge and limited experience, a thorough experimental study of the problems has been undertaken. The extension men, in this case the extension agronomist and the county agents bring to the study of this problem a wealth of observation and experience which is likely to guide the work of investigation, and most certainly aid in centering attention on the economic gain for which the work is justified.

Massachusetts greenhouse vegetable growers have long suffered serious losses from the red spider on cucumbers. It was for the extension specialist to translate this loss into terms of dollars and cents before recognition of the need of more research on this problem was fully appreciated. It was found that the life history of the red spider as a type had been thoroughly studied, but a practical way for the cucumber grower to destroy the pest was still unknown. So this problem was taken to the research entomologist and real progress was made. I believe the entomologist considers this problem solved, for an effective spray was evolved and ways and means of applications worked out. To the extension specialist this problem is still unfinished for the following reasons:—(1) The greenhouse cucumber growers have not generally accepted the method as practical; (2) They report frequent injury to flowers and foliage through what seems to be a not sufficiently careful preparation of the spray; (3) There seems to be a lack of outstanding demonstration of the money saved through the limited adoption of the practice. We need to carry this work a step farther.

We want to devise a means of cleaning the red spider from the greenhouse, and improve methods of keeping it out, if that be possible. Until we know whether these things are practical, we need to continue our research in this problem. Illustrations might easily be multiplied.

Extension workers have been able to draw on an accumulation of research work of the past 40 years. They have eagerly sought, sorted and dispensed what fitted their needs. To-day the experiment stations are deluged with problems and projects which are being pressed for solution. It is for the extension forces to lend

their best service to a complete and full understanding of the fundamental importance of sound research. It is necessary to get adequate support for this work. Upon this depends the proper advancement of our business.

The activities of the research worker rarely bring him into the public gaze. The applause that may come to the man who is working in the field does not even echo in the research laboratory. The research worker is as human as the extension man. He has felt what seems to him a lack of appreciation since the development of agricultural extension work because it has been so easy to contrast the publicity given to the man in the field and the man in the laboratory.

I have already referred to the feeling of the extension specialist about problems of long standing which have not been completely solved. As he has gone to the experiment station with his trouble there has been a tendency on the part of the investgator to feel that this new man was making himself a censor where he had no license, and that his knowledge was cursory, not thorough or fundamental. In many instances this criticism has been more or less just.

It is my belief that within the past year or two there has grown up a feeling of respect and appreciation on the part of men in each branch of the service, for those in the other. Certainly the investigator has at his call the man who has been in so close contact with the actual problems that he can render invaluable assistance. On the other hand, the extension man has an increased appreciation of the necessity of fundamental research; the need of an appreciation of science in solving the problems that daily confront him.

Business moves fast. Often investigation goes slowly. To the real scientist nothing is proved until it is proved. The business of the farm is far from exact. To-day we plan, tomorrow we change our plan. We say that conditions compel it. The farmer, particularly the alert vegetable grower not infrequently has found a way out of a problem by the time the project of the experiment station is organized and just getting under way. And they who should lead, follow.

How many times have we accomplished results but never known how. The scientist knows that knowledge is essential to instruction, to progress.

Our extension forces must make it a part of their business to recognize the essential nature of agricultural research. It is most encouraging that signs of such recognitions are abundant. In my judgment they must do more, they must pass on this feeling of its importance to those who control the purse strings of the states and nation so that our unsolved problems may have adequate study and receive the light of real scientific investigation.

Surely the development of the whole depends on the development of its parts. Our agricultural education depends in no small part on the functioning of sound research to continue a suitable growth and give service in the field and class room.

Status of Extension and Research Work with Vegetables

The development of the vegetable gardening business has been such that it has seemed little dependent upon any assistance from the agricultural college or experiment station, until recent years. This change may have come from a better understanding by the grower of the functions of the college and experiment station, perhaps through the activities of the extension service.

Today there is a demand, at least in the localities with which I am familiar, for real extension work. The extension worker soon discovers the need for real investigation and the more intense the study, the more is this need recognized.

There is a mass of data, more or less digested, which has been accumulating for a generation and the extension worker has been drawing on this as available and where applicable. He finds, however, that there are problems of plant production and improvement, soil, management, the maintenance of fertility, insect and disease control, engineering farm management and marketing that need research study to keep our specialty in rank with progressive business.

The funds available for research are limited and it is necessary to work out a program which will recognize problems in the order of their economic importance. We are trying to do that in Massachusetts.

Organization within a state which will place the development of a program in the hands of an experienced specialist, bring about the thoughtful cooperation of leading business vegetable growers, encourage the cooperation of the various agencies of the agricultural college, state department of agriculture and the organizations of vegetable growers, seems to me nearly ideal, in making the best program and the best progress.

With such a program and the right cooperation, the research work will receive its proper recognition and ways and means be found to give the real problems of our specialty their due study.

In Massachusetts, we consider the problem of maintaining soil productivity a principal one. It is clear that other states feel the same need. A study of the census shows that the decrease in horses in Massachusetts from 1910 to 1920 is such that 13,000 less acres can be furnished with 20 tons of stable manure per acre in 1920 than in 1910. It will require a cash expenditure of between $1,200,000 and $1,400,000 to replace the plant food formerly obtained from stable manure. Even then we lack that all important effect of the organic matter for which no equally efficient substitute has been found. Here we have a real problem for investigation and we are at it. The workers in every state need to cooperate to the fullest extent to solve this problem. The research man needs to check every move; the extension worker needs to give every assistance. The more intensive the production the greater the problem.

The relationships between extension work and research must be very intimate and sympathetic, if our service institutions in which most of us are laborers, are to render the service which the public welfare requires and which we are bound to give.

Effects of Certain Physiological Factors on Blossom Drop and Yield of Tomatoes

By W. A. RADSPINNER, *Experiment Station, Stillwater, Okla.*

BLOSSOM drop of tomatoes refers to the separation of the blossom from the remainder of the plant at the abscission layer which is usually located on the stem about three-fourths of an inch below the receptable. This dropping may occur at any age of the blossom, but seldom after the fruit has set, and it occurs only during periods when the air is extremely hot and the relative humidity low.

During hot, dry weather, blossom drop of tomatoes has been the limiting factor of the production of that crop since its first introduction into Oklahoma. This disease is most prevalent and most destructive in the western two-thirds of Oklahoma, western Kansas and northern Texas. Similar troubles have also been reported from West Virginia and Florida, and will generally be found wherever hot drying winds strike the plants while in bloom. During mid-summer in Oklahoma, 100 percent of the crop is often lost due to blossom drop.

Gardner, Bradford, and Hooker[1] have classified the causes of unfruitfulness, sterility, and the failure of fruits to set, into two main classes—those internal to the plant including evolutionary tendencies, genetic influences, and physiological factors causing poor development after pollination; and those external to the plant due to environmental influences. Because a large part of the abscission of blossoms in tomatoes occurs while the blossoms are immature, the class of internal causes mentioned above as well as all pollination and fertilization causes, are eliminated as probable causes of blossom drop of tomatoes.

Coit and Hodgson[2] have contributed the cause of the abscission of blossoms and young fruits from petal drop to an inch in diameter as due to abnormal water relations which serve as a stimulus to abscission. In this connection Heinicke[3] tentatively concludes that unfavorable conditions of nutrition and water supply are among the basic factors which cause the normal drop of flowers and partially developed fruits of the apple. Sorauer[4] has proven that the leaves of grapes and dwarf pears form abscission layers and drop, due mainly to a lack of moisture. These investigations prove that blossom drop is due to effects of various physiological factors insofar as these factors affect pollination, or setting of fruits. Causes of abscission of immature blossoms are not given. Because tomato blossoms ready to drop reveal a drying

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[1]Gardner, Bradford, and Hooker: Fundamentals of Fruit Production. P. 488. 1922.

[2]Coit, J. and Hodgson, R. W. Cal. Agr. Exp. Sta. Bul. 290, 1918.

[3]Heinicke, A. J. Cornell Uni. Agr. Exp. Sta. Bul 393. 1917.

[4]Sorauer, P. Pflanzenkrankeiten. 3 to Auflage. 1: 275-285. 1909.

out of tissue at the node where abscission takes place, it is possible that water relations play an important part in their abscission.

Gardner, Bradford and Hooker[5] cite cases proving that water relations are somestimes causes of formation of abscission layers and dropping of blossom in fruit trees.

Floyd[6] found abscission of bolls in cotton due indirectly to a water deficit in leaves and stems.

Investigations to determine the causes of the shedding of immature tomato blossoms have been carried on in Oklahoma for 14 years. The work was started as early as 1908 by Morris and continued by Booth in 1910, Herron in 1915, Cross in 1917, White in 1920, and the author in 1922. Morris conducted variety tests, pruning tests and soil fertility tests, but obtained successful results only of minor importance. He also shaded some of the plants, but found no clue as to a remedy for the trouble.

Booth sacked some blossoms on the plant and placed damp sponges in the bottom of the sacks to increase the humidity and lower the temperature. The blossom drop was greater in the sacks, "probably due to irritation of the blossoms caused by the wind blowing the sacks around." Lack of pollination as a cause of blossom dropping was proven to be of no importance. At this time, Booth thought the thrips were eating the centers out of the pollen grains causing blossoms to drop from poor fertilization: however, later he found this not true. He also discovered that diseases had no bearing whatever on the dropping of blossoms His most important experiment, however, was one comparing irrigated and non-irrigated plants. The yield of the irrigated plot was 41 per cent over that of the non-irrigated plot, while the number of fruits produced was increased 18 per cent by irrigation.

Cross duplicated some of the work of the others with similar results, except no difference occurred between the yields of irrigated and non-irrigated plots; however, he obtained increased yields by using a straw mulch. Later (1919), he used the overhead system of irrigation, shading some of the plants and leaving some unshaded. The irrigated, shaded plants produced 14¾ pounds per plant while the irrigated unshaded plants averaged only 4½ pounds per plant. It was the opinion of Cross that the hot, dry winds and extremely severe sunshine caused poor pollen production, causing a lack of fertilization and resulting in blossom drop. Booth, however, had previously eliminated poor pollination and fertilization as causes of abscission of immature blossoms.

White repeated some of the experiments of the previous investigators obtaining similar results.

These investigators have worked on the following probable causes: extremely hot weather, an over-rapid growth due to an excess of nitrogenous fertilizers, lack of proper nutrients in the

[5]Gardner, Bradford & Hooker. Fundamentals of Fruit Production, P. 516, 1922.

[6]Floyd, F. E. Trans. Roy. Soc. Canada (Ser. 4) 10: (Sec. 4) 55-61. 1916.

soil, deleterious substances in the soil, insects, winds, lack of moisture, extremes of temperature both day and night, varietal susceptibility, poor pollination and humidity. Their work has not heretofore been published.

In an effort to determine the probable physiological causes of the abscission of immature tomato blossoms, the author conducted the following experiment during the summer of 1922. The work was conducted in a partially sunken greenhouse. The greenhouse is 50 feet long east and west by 11 feet wide. The floor is concrete and located 3 feet below the surface of the ground with concrete walls to the level of the ground. Windows above ground 2 feet high, together with the frames, make the total distance from the floor to the eaves 5 feet 6 inches. The sash forming the even span roof are standard 6 feet by 3 feet and slope north and south, making a distance of 8 feet from the floor to the comb of the roof. A heavy soil of a poor clay compost was spread seven inches deep on the floor. The experimental plot was 38 feet by 4 feet, extending along the north wall of the greenhouse.

There were 60 plants, 30 June Pink and 30 Yellow Pear tomatoes. The June Pink was used because it is the most popular standard tomato for this section and the Yellow Pear was used because of its habits of producing blossoms abundantly. The plants used had been grown from seed sown in flats April 4th. The young plants had been potted in two inch and later four inch pots. On May 24, when almost two feet high the plants were transplanted from the four inch pots to the permanent plot. The plants had not bloomed when transplanted.

The bed was partitioned into three large plots each 4 feet by 12 feet 7 inches. These plots were labeled A, B, and C respectively from west to east. Plot A was watered with one pint of water per plant per week, plot B one pint of water per plant three times per week, and plot C one pint of water per plant six times per week.

Each of the above plots consisted of 20 plants, 10 of each variety. The plants were arranged 10 in a row, the June Pink in the south row and the Yellow Pear in the north row. The north row was 16 inches from the wall, the two rows were 21 inches apart and the south row 11 inches from the edge of the bed. The plants were 15 inches apart in the rows.

When the plants were set, each large plot was divided into 10 sub-plots according to fertility. Each sub-plot consisted of two plants, one June Pink and one Yellow Pear. The plants were numbered from one to 20 in each plot beginning at the west end of each plot, the June Pink receiving the odd numbers and the Yellow Pear, or north row, the even numbers. The sub-plots were fertilized directly after setting as follows: Sub-plot 1 of each large plot consisted of plants 1 and 2, sub-plot 2 consisted of plants number 3 and 4, etc.

Sub-Plot	Fertility Per Plant.
1.	Barnyard manure 3 inches deep.
2.	Milk of lime (1½ ounces CaO).
3.	Check.

4. Nitrate of soda 25 grams.
5. Acid Phosphate 50 grams.
6. Sulphate of potash 25 grams.
7. Nitrate of soda 25 grams, acid phosphate, 50 grams.
8. Nitrate of soda 25 grams, sulphate of potash, 25 grams.
9. Acid phosphate 50 grams, sulphate of potash 25 grams.
10. Nitrate of soda 25 grams, acid phosphate 50 grams, sulphate of potash 25 grams.

The fertilizers were applied in strips 12 inches wide, running north and south. These were wet down equally on all plots and then a mulch of oat straw applied to a depth of five inches.

Water applied was measured in a pint tin cup and poured into a six inch glass funnel. The tube of the funnel extended through the straw to the surface of the ground during watering so that no water was held by the straw for evaporation. Each week the plants were measured as to height and records taken on blooming, blossom drop and fruit set. The plants were constantly kept pruned to a single stem and the height measured at the terminal growth bud. The plants were staked and kept tied at all times.

The object of using the various fertilizers on underwatered, normally watered, and overwatered plots, was to see whether or not the amount of soil moisture would influence the effects of the various fertilizers.

Other factors were kept controlled as far as possible on all plots. Insects and rodents were almost entirely excluded. For ventilation, each alternate sash on the southern sloping roof was replaced by muslin and all of the windows on the south side between the ground and eaves were replaced by cheese cloth. The north side was kept closed. This allowed a flow of air through the cheese cloth to the extent that pollination was normal. The air escaped through the muslin of the roof. The plots being on the north side of the greenhouse were not wet by rains. The remaining glass of the roof was whitewashed to produce the same amount of shade as the muslin. The results of the work may be reviewed under four headings.

Effects of Fertilizers on Blossom Drop, Fruit Production and Growth

Tables I and II show that potash fertilizers had some effect on the setting of fruit, however, this effect was small and not constant. With both varities, the plots receiving a normal amount of water produced highest fruit sets on sub-plots fertilized with potash alone. This did not hold true where the soil moisture was deficient or excessive. The complete fertilizer in most cases produced a fairly high setting of fruit. Blossom drop was greatest in most cases where both nitrogen and phosphorus were applied, leaving the plot deficient in potash. The importance of potash in fruit production and setting of fruit has long been known. The check plots of June Pink produced a slightly higher total yield and total number of fruits while the plot limed produced fruits of slightly higher average weight.

The fertilizers applied did not materially alter the analysis of the leaves or growth of the plant.

Effect of Soil Moisture on Blossom Drop, Fruit Production and Growth

An analysis to determine the moisture content of the soil was made on June 27. Soil samples were taken from the middle of each of the three plots by obtaining soil 12 inches from the plant. A sample of soil one inch in diameter and extending the entire depth of the soil was used. Two analyses were made of each sample with averages as shown in the following table.

TABLE I SHOWING ANALYSIS OF A SINGLE LEAF FROM EACH PLANT, YIELD, BLOSSOM DROP, FRUIT SET AND GROWTH OF JUNE PINK.

No. of Plant	Wt of leaf (grams)	Entire Leaf (per cent)			Total Solids (per cent)		Increase in height of plant, feet and inches May 29 to July 10	No of fruits	Crop Production		No of Blossoms dropped by July 5	No of fruits set by July 5	Percent of fruit set
		Moisture	Combustible matter	Ash	Combustible matter	Ash			Wt of crop	Average wt. per fruit (Grams)			
PLOT A.													
1 M	4.8660	86.46	9.92	3.62	73.28	26.72	2 - 9	1	135	135	5	9	64.3
3 L	4.2838	86.93	9.14	3.93	69.91	30.09	2 - 0	3	198	66	4	8	66.7
5 C	3.4936	87.09	8.81	4.10	68.25	31.75	1 - 6	4	223	56	8	6	42.9
7 N	3.7686	87.03	9.26	3.71	71.42	28.58	2 - 7	2	164	82	10	9	47.4
9 P	3.2770	87.24	8.96	3.80	70.25	29.75	1 - 7	2	202	101	6	9	60.0
11 K	4.1912	87.13	9.24	3.63	71.82	28.18	2 - 1	2	136	68	7	11	61.1
13 NP	4.8680	87.00	8.92	4.08	68.61	31.39	1 - 0	5	213	43	10	9	47.4
15 NK	2.8674	84.81	11.24	3.95	74.01	25.99	1 - 9	5	246	49	12	7	36.8
17 PK	3.4077	85.42	10.37	4.21	71.10	28.90	2 - 1	4	168	42	11	9	45.0
19 NPK	2.2184	85.90	10.22	3.88	72.48	27.52	1 - 9	2	156	78	2	5	71.4
Total	37.2417	.....	.....	....	.....	.....	19 - 1	30	1841	..	75	82	
Average	3.7242	86.50	9.61	3.89	71.11	28.89	1 - 11	3	184.1	61.4	7.5	8.2	54.3
PLOT B.													
1 M	3.9264	86.10	10.05	3.85	72.28	27.72	1 - 8	7	293	42	10	10	50.0
3 L	4.0573	84.70	11.51	3.79	75 21	24.79	2 - 9	2	224	112	10	5	33.3
5 C	3.4083	85.36	10.73	3.91	73.29	26.71	3 - 0	5	267	53	16	10	38.5
7 N	2.4672	83.84	11.50	4.66	71.11	28.89	1 - 11	2	155	78	6	9	60.0
9 P	5.4334	86.36	10.09	3.55	73.96	26.04	2 - 5	5	331	66	11	12	52.2
11 K	2.4032	84.09	11.18	4.73	70.27	29.73	1 - 3	2	140	70	0	10	100.0
13 NP													
15 NK	2.6904	86.12	9.55	4.33	68.78	31.22	0 - 9	2	159	80	3	6	66.7
17 PK	5.4500	86.30	10.13	3.57	73.92	26.08	1 - 10	4	257	64	7	9	56.3
19 NPK	4.1420	86.94	9.68	3.38	74.13	25.87	0 - 8	3	177	59	11	11	50.0
Total	33.9782	.....	.....	....	.....	.....	16 - 3	32	2303	..	74	82	
Average	3.7754	85.53	10.49	3.98	72.55	27.45	1 - 10	3.56	256.0	71.9	8.2	9.1	56.3

No. of Plant	Wt of leaf (grams)	Entire Leaf (per cent)			Total Solids (per cent)		Increase in height of plant, feet and inches May 29 to July 10	No of fruits	Crop Production		No. of Blossoms dropped by July 5	No. of fruits set by July 5	Percent of fruit set
		Moisture	Combustible matter	Ash	Combustible matter	Ash			Wt. of crop	Average wt. per fruit (Grams)			
PLOT C.													
1 M	3.9400	86.30	10.51	3.19	76.72	23.28	3 - 4	3	368	123	8	15	65.2
3 L	3.6442	86.34	10.33	3.33	75.64	24.36	3 - 2	5	425	85	12	10	45.5
5 C	4.2531	87.12	9.78	3.10	75.94	24.06	2 - 9	5	503	101	16	16	50.0
7 N	4.1598	85.67	11.24	3.09	78.43	21.57	3 - 6	3	246	82	10	6	37.5
9 P	3.9648	87.09	9.09	3.82	70.44	29.56	2 - 2	6	462	77	13	13	50.0
11 K	4.0814	88.73	7.53	3.74	66.78	33.22	1 - 8	3	246	82	3	16	84.2
13 NP	3.4400	86.24	9.85	3.91	71.57	28.43	2 - 9	4	401	100	7	12	63.2
15 NK	3.7404	87.30	8.98	3.72	70.72	29.28	1 - 11	3	315	105	1	9	90.0
17 PK	4.7296	86.95	9.52	3.53	72.95	27.05	2 - 6	5	366	73	6	10	62.5
19 NPK	4.3367	85.88	9.60	4.52	67.98	32.02	1 - 1	4	269	67	0	8	100.0
Total	40.2900	.....	.....	....	.....	.....	24 - 10	41	3601	..	76	115	
Average	4.0290	86.76	9.64	3.59	72.72	27.28	2 - 6	4.1	360.1	87.8	7.6	11.5	64.81

M—Manure
L—Lime
C—Check
N—Nitrogen
P—Phosphorus
K—Potassium

TABLE II SHOWING ANALYSIS OF A SINGLE LEAF FROM EACH PLANT, YIELD, BLOSSOM DROP, FRUIT SET, AND GROWTH OF YELLOW PEAR. JUNE 27—1:00-3:00 P. M. TEMPERATURE AT 11:00 A. M.—92° F.

PLOT A.

No. of plant	Wt. of leaf (grams)	Entire Leaf (per cent)			Total solids (per cent)		Increase in height of plants feet and inches May 29 to June 26	Blossoms dropped by June 28	No. of fruit set by June 28th	Per cent fruit set
		Moisture	Combustible matter	Ash	Combustible matter	Ash				
2 M	5.9596	87.31	9.13	3.56	71.96	28.04	3 - 2	15	7	31.8
4 L	9.1269	87.34	9.34	3.32	73.77	26.23	3 - 3	21	12	36.4
6 C	7.7332	87.03	9.73	3.24	75.04	24.96	3 - 3	19	13	40.6
8 N	6.9554	85.51	11.15	3.34	76.97	23.03	2 - 10	19	15	44.1
10 P	7.8461	85.70	11.03	3.27	77.12	22.88	2 - 8	20	14	41.2
12 K	7.3571	87.44	9.06	3.50	72.14	27.86	2 - 7	21	10	32.3
14 NP	7.4798	84.80	11.71	3.49	77.01	22.99	2 - 11	30	6	16.7
16 NK	5.7242	85.38	10.96	3.66	74.97	25.03	2 - 8	21	13	38.2
18 PK	6.6514	85.90	10.36	3.74	73.49	26.51	2 - 11	23	7	17.5
20 NPK	7.5252	87.19	9.82	2.99	76.63	23.37	2 - 10	21	15	41.7
Total	72.3589	.....	....	....	.....	.....	29 - 1	210	112	
Average	7.2359	86.36	10.23	3.41	74.91	25.09	2 - 11	21.0	11.2	34.0
PLOT B.										
2 M										
4 L	8.4316	86.95	9.69	3.36	74.23	25.77	3 - 0	16	12	42.9
6 C	6.9800	86.21	10.36	3.43	75.14	24.86	2 - 11	23	15	39.5
8 N	......	.....	.....	....						-
10 P	6.9099	86.63	9.92	3.45	74.17	25.83	3 - 1	18	13	42.0
12 K	6.7515	87.45	9.15	3.40	72.92	27.08	3 - 0	16	14	46.7
14 NP	6.9595	86.20	10.76	3.04	77.96	22.04	2 - 8	21	13	38.2
16 NK	......	.....	.....	....						
18 PK	7.2298	87.54	9.14	3.32	73.55	26.65	3 - 0	12	10	45.5
20 NPK	7.6078	87.56	9.39	3.05	75.48	24.52	3 - 5	18	15	45.5
Total	50.8701	.....	....	....	.....	.....	21 - 1	124	92	
Average	7.2672	86.93	9.77	3.29	74.75	25.25	3 - 0	17.7	13.1	42.9

PLOT C.

No. of plant	Wt. of leaf (grams)	Entire Leaf (per cent) Moisture	Entire Leaf (per cent) Combustible matter	Entire Leaf (per cent) Ash	Total solids (per cent) Combustible matter	Total solids (per cent) Ash	Increase in height of plants feet and inches May 29 to June 26	Blossoms dropped by June 28	No. of fruit set by June 28th	Per cent fruit set
2 M	10.8300	89.53	7.87	2.60	75.19	24.81	3 - 10	20	21	51.2
4 L	8.0300	89.29	8.07	2.64	75.35	24.65	3 - 9	18	19	51.4
6 C	9.1284	89.62	7.78	2.60	74.97	25.03	3 - 10	15	18	54.5
8 N	12.2686	92.33	5.21	2.46	67.95	32.05	3 - 11	18	17	48.6
10 P	10.0892	89.76	7.56	2.68	73.80	26.20	3 - 9	16	20	55.6
12 K	12.7058	88.88	8.80	2.32	79.14	20.86	3 - 8	13	20	60.6
14 NP	6.7683	88.37	8.93	2.70	76.81	23.19	3 - 4	18	9	33.3
16 NK	10.5922	88.33	9.04	2.63	77.48	22.52	3 4	19	20	51.3
18 PK	8.6454	89.63	8.39	2.58	76.46	23.54	3 - 5	19	24	55.8
20 NPK	13.0512	88.69	8.75	2.56	77.38	22.62	3 - 6	18	20	52.7
Total	102.1091	.....	....	....	.....	.....	36 - 4	174	188	
Average	10.2109	89.38	8.04	2.58	75.45	24.55	3 - 8	17.4	18.8	51.5

M—Manure
L—Lime
C—Check
N—Nitrogen
P—Phosphorus
K—Potassium

Soil Analysis, June 27th.

Analysis	Plot A	Plot B	Plot C
1	15.172	19.244	23.360
2	15.107	18.064	23.029
Average	15.140	18.654	23.194

The small differences between plots is explained by the fact that to a certain limit, the plants will use the water somewhat in proportion to its availability. The plants in plot C were large due to the large water supply and would consume much more water per plant than would the small plants in plot A.

Tables I and II show an appreciable relation of the amount of moisture in the soil to blossom drop. The per cent fruit set of the three plots in Table I was 54.3, 56.3 and 64.8 respectively, although the actual number of blossoms dropped was not proportional to the amount of water supplied. With the Yellow Pear, the percentage of fruit set varied even more than with the June Pink, the average being 34.0, 42.9, and 51.5 per cent respectively. The actual number of fruits set was somewhat proportional to the amount of soil moisture present. These results conform with those of Coit and Hodgson, Heinicke and Sorauer previously mentioned in this paper.

In addition to the important effect of soil moisture on per cent of fruit set, the production and size of fruits set were affected. With June Pink, the average number of fruits produced per plant for plots A, B, and C respectively, was 3.00, 3.56 and 4.10; average weight per fruit 61.4,71.9 and 87.8 grams, making the average weight of fruit produced 184.1, 256.0 and 360.1 grams per plant for the plots A, B, and C respectively.

With Yellow Pear, the average number of fruits produced per plant was 7.78, 11.50, and 13.67 and the average weight per fruit 6.44, 8.16 and 15.23 grams respectively for the three plots. This made an average total yield per plant of 50.11, 93.83 and 208.11 grams respectively.

In addition to the large increase in fruit set and fruit production due to an increase in water supply, there was a corresponding increase in height of plants. From May 29 to July 10, a period of 42 days, the average gain in height of plants for plots A, B, and C of the June Pink variety was 1 foot 11 inches, 1 foot 10 inches and 2 feet 6 inches, respectively. For the Yellow Pear, this increase was 2 feet 11 inches, 3 feet, and 3 feet 8 inches, respectively, for the three plots. This increase in size is also shown by the weights of leaves taken 2 feet 6 inches from the ground from June Pink plants. On July 5, the average weight of a leaf per plant was 3.7242, 3.7754, and 4.0290 grams respectively for the three pots, and the Yellow Pear leaves taken 3 feet from the ground on June 27 averaged 7.2359, 7.2672, and 10.2109 grams respectively.

The analysis of the leaves from the three plots receiving low, medium and high moisture supplies in the Yellow Pear, shows an increase in moisture and decrease in combustible matter and ash as water supply is increased. This does not hold exactly true

with the June Pink. Considering the total solids only, it is interesting to note the increase in per cent combustible matter (though not large) and a decrease in ash in plants receiving the highest moisture, yet the percentage of total solids in these plants is lowest. The high percentage of combustible matter is partially explained by the larger leaves being more efficient in photosynthetic processes.

Effect of Relative Humidity on Blossom Drop

The relation of temperature to blossom drop may be seen in the following two tables, the first the June Pink and the second the Yellow Pear. Each number represents the average temperature at 11:00 A. M.

		May 31 to June 7	June 7 to June 14	June 14 to June 28	June 28 to July 5
		June Pink			
Temperature		83.5°F	90.5°F	98.0°F	95.0°F
Blossoms Dropped	A	9	23	41	2
	B	2	16	44	11
	C	2	14	51	9
	Total	13	53	136	22
		Yellow Pear			
Blossoms Dropped	A	7	7	196	15
	B	11	16—5	160	18
	C	0	7	167	3
	Total	18	30	523	36

Even considering that the third column of figures in the above table represents the number of blossoms dropped for the preceding two weeks, the relation of temperature to dropping of blossoms during that period is easily noticeable especially with the Yellow Pear. With this variety 262 blossoms dropped per week where the average temperature was 98° F. as compared to 30 the preceding week where the temperature had been but 90.5° F. The extremely low dropping of blossoms with the average temperature dropping but 3° during the next seven days is explained in the following paragraph.

Effect of Relative Humidity on Blossom Drop

Observations show that practically no rains occurred from the beginning of the experiment to June 24, and that the relative humidity, especially during the latter part of that period, was very low. From June 24 to July 5, the relative humidity was very high with rain almost every day during that period. The rains were short and generally in the evening with hot sultry days of high relative humidity following. The above table shows an average temperature of that period of 95° F. yet observations and counts show that very few blossoms dropped, but a large number set fruit. The readings of the table are based on a basis of ten plants of each variety per plot. With the June Pink during the week of high relative humidity, there were 22 blossoms dropped as compared to 68 each of the two preceding weeks with the same

temperature, but low humidity. With the Yellow Pear, the difference is even more noticeable with 36 during the hot period when the relative humidity was high and 264 during the hot period when the relative humidity was low. The number of blossoms available to drop or set fruit was very constant throughout the entire experiment. The above results are similar to those of Coit and Hodgson[7] who found the abscission of blossoms of Washington Naval Oranges to occur mostly during that part of the day when the temperature was high and the relative humidity low.

Summary

From the data recorded in this preliminary report of probable causes of the abscission of immature blossoms in tomatoes, the results may be summarized as follows. These results agree, to a certain extent, with the conclusions drawn by investigators cited by Gardner, Bradford, and Hooker[8] that low atmospheric humidity, high temperature, and a limited moisture supply often induce moisture deficits in trees, leading to the formation of an abscission layer and dropping of blossoms.

I. Immature tomato blossoms drop due to physiological rather than to genetic or pollination causes.

II. Water deficits in the soil play an important part in influencing the dropping of the blossoms. An increase of soil moisture caused a corresponding increase in per cent of fruit set, size of fruits, size of plants, moisture content of leaves, and a decrease in percentage of ash.

III. Extremely high temperatures caused the blossoms to drop probably by increasing transpiration rates. Blossoms did not drop during cool, dry weather in late spring, but dropped in abundance during hot, dry weather.

IV. Low humidity caused the blossoms to drop probably by increasing transpiration rates. With other factors constant the same blossoms dropped more when the relative humidity was low than when it was high.

V. Fertility of the soil had but minor effects on the dropping of blossoms. A lack of potash had a slight tendency to cause abscission.

[7]Coit, J. E. and Hodgson R. W. Cal. Agr. Exp. Sta. Bul. 290, 1918.

[8]Gardner, Bradford and Hooker. Fundamentals of Fruit Production, P. 516. 1922.

Preliminary Studies on the Sulfur Content of the Tomato

By R. S. MARSH, *University of Missouri, Columbia, Mo.*

A RECENT investigation on the sulfur content of apple tree tissues by the sodium peroxide method showed that the sulfur content was of the same order as phosphorus. Although it might be thought that the seasonal variation in two kations such as phosphorus and sulfur would parallel each other, it was found that in apple tree tissues there is a remarkably persistent inverse relation. The sulfur curve was found to be correlated directly with the variations in hydrogen ion concentration. To determine whether these relationships are peculiar to apple tissue, or whether they are of general occurrence in plant tissues, a similar study was made with tomato plants.

Tomatoes grown in the greenhouse were treated with such fertilizers as acid phosphate; manure; mixed fertilizer (2½-12-5); acid phosphate and potassium sulfate; and manure, nitrate plus heavy water. The plants were given these treatments after transplanting when about 3 to 5 inches high. Samples were taken of seedling plants and at two week intervals thereafter samples from individual plants were taken of the tips, of the region of blossoming, of the region of fruiting, and of the base. Samples of entire field-grown plants were taken at various periods. Some of these plants were given mixed fertilizers, others acid phosphate, and still others received no fertilizer treatment.

The amount of sulfur present in tomato tissue was found to be from 2½ to 4 times the amount of phosphorus, while the nitrogen content was only about double the sulfur content.

In percentages of dry-weight, the sulfur content was found to increase from tip to base through the four zones as shown below:

Tip	1.29	1.19	.69	1.25
Region of blossoming	1.32	1.79	.76	1.60
Region of fruit	1.56	1.99	1.38	1.21
Base	2.17	2.03	2.22	1.15

The data presented are representative of the analyses obtained. The variation between similar zones are due to treatment.

It is evident from these figures that the older the tissue the higher the sulfur content. This is also brought out by analysis of the entire aerial portion of greenhouse plants at various ages:

	Sulfur in percentages of dry weight
Seedling plants 3 inches high	0.91
Potted plants forming fruit buds	1.37
Plants with fruit set	1.40
Plants with fruit set (19 days later)	1.50

The relative percentages of phosphorus and sulfur on the dry weight basis in the different zones are as follows:

	P	S	P	S	P	S
Tip	0.558	1.29	0.513	0.69	0.377	0.87
Region of blossoming	0.417	1.32	0.590	0.76	0.349	0.91
Region of fruit	0.347	1.56	0.319	1.38	0.271	1.06
Base	0.374	2.17	0.251	2.22	0.342	1.21

These data show that where the sulfur is high the phosphorus is low. The amounts of these elements seemed to run inversely to each other just as in apple tree tissues where this relation occurred in a particularly striking way in spurs. Such data suggest that sulfur may liberate phosphorus from the older tissues for translocation to younger growing tissue.

On the other hand, sulfur seems to parallel the hydrogen ion concentration. On buckwheat, Haas found in seedling plants low hydrogen ion concentration, while mature plants showed a high hydrogen ion concentration. By zoning a sweet clover plant he found a gradient in hydrogen ion concentration in this plant which gave low acidity in the tips and high acidity in the base. Dr. Rosa found that the PH value in tomato-plant tips to be 5.7 and in the fruiting region 4.8. The fact that these same correlations were found in apple tree tissue suggests that some fundamental relationship must exist between sulfur, hydrogen ion concentration and phosphorus.

The fertilizer treatments were found to cause much variation in the amount of phosphorus and sulfur present. This can be shown best by comparing the check with the acid phosphate treatment.

Phosphorus and Sulfur in Percentages of Dry Weight

	Check		Acid Phosphate	
	P	S	P	S
Tip	——	1.25	0.451	1.29
Region of blossoming	0.238	1.60	0.465	1.32
Region of fruit	0.338	1.21	0.418	1.56
Base	0.344	1.15	0.328	2.17

The data show that when acid phosphate was added the sulfur and phosphorous content was markedly increased. It seems that the addition of acid phosphate has also changed the order in which these elements were present in various zones of the check plot. The increased amounts of these two elements does not necessarily indicate that they are required in these larger quantities. The change of the region of maximum phosphorus content from the base to the region of blossoming, and of the region of maximum sulfur content from the region of blossoming to the base, may be of greater significance since this second distribution of sulfur and phosphorus occurs more generally in vigorous and productive plants.

In general these studies show the desirability of further investigation on sulfur and its relation to plant life.

A Preliminary Test of Stored Cut Seed Potato Stock

By K. C. Westover, *Experiment Station, Morgantown, W. Va.*

SOME of the most extensive potato growers of the Louisville section of Kentucky, hold that potato seed stock can be cut and held in cold storage for some time before planting, without detrimental effects to yield. A few even believe that such stock outyields freshly cut tubers, although they have no data to substantiate their belief. It can be readily appreciated that any practice which would relieve the early spring labor congestion would be of great value, especially were it to increase yields. With this point in mind a preliminary test on the effects on yield of cut seed, held for varying lengths of time in cold storage, was begun in October of 1921.

All seed stock was of the same strain of Carman No. 3. An ammonia cooled refrigerator, in which it was possible to automatically control the temperature to within a few degrees, was used for storage. A temperature of 38 to 42* degrees F., and a humidity of approximately 87 per cent was maintained during the entire storage period of 189 days. Thermograph and hydrograph records were kept as a check on refrigeration. An electric fan was used to circulate the air in storage. The containers used for the different lots of seed were bushel baskets.

Seed stock was cut in 30 pound lots according to recommended practices, at approximate two week intervals from October 17, 1921, to April 24, 1922. The stock was cut in storage where it had been kept until required for the test. Check lots of equal weight of uncut tubers were added to the test at different times during the storage period, so that a comparison of weight losses of the treated and untreated stock for different lengths of time in storage, might be obtained (Table I). Marked withering and discoloration occurred in only the first two cut lots which were in storage longest. The other lots were firm and in good condition at planting time. The checks and a few of the last cut lots showed slight indications of sprout development.

TABLE I.

Periods of Storage and Loss in Weight of Treated and Untreated Tubers

Treatment	Cut	Cut	Not Cut	Cut	Cut	Not Cut	Cut	Cut
Field planting, number (row)	1	2	..	3	4	..	5	6
Days cut, in storage	189	175	170	160	144	144	129	114
Loss of weight, percent	13.3	11.7	3.3	11.7	11.7	5.0	11.7	10.0
Treatment	**Cut**	**Cut**	**Not Cut**	**Cut**	**Cut**	**Not Cut**	**Cut**	**Cut**
Field planting, number (row)	7	8	..	9	10	..	11	12
Days cut, in storage	98	82	82	68	54	54	39	23
Loss of weight, percent	11.7	9.2	3.3	5.0	5.0	2.5	5.0	3.3

*Circ. 20 of N. H. Sta. "Storage of Potatoes" by O. Butler.

The weight of all lots was recorded on the day of planting. The checks with a sufficient quantity of similar stock held under the same storage condition, were cut to serve as field checks. The storage data showed that the loss in weight in the cut lots was quite rapid for the first 100 days, but that in the checks the loss occurred within the first few days, with only little weight loss thereafter. Cut stock lost approximately from 2 to 4 times as much as the checks according to the length of the time stored (Table I).

When planted the plots were arranged as follows: The two blocks of rows, each contained three series, or replications. Each series or replication was composed of a 30 foot row planted with seed stock from each of the cut lots. The rows occurred consecutively according to the length of time the seed stock had been cut in storage. Check rows were placed at the beginning, every fifth row, and at the end of each replication. Waste rows flanked the ends of each of the blocks. The spacing of the rows and of the hills in the rows was the same throughout the planting. Cultural methods were practiced uniformily at the same operation throughout the growing period.

The planting was closely observed during the growing season. The plants broke the surface of the soil at about the same time over the entire planting. The stand was good and in only the rows planted from seed of the two lots longest treated in storage, was there any marked lack of vigor in the plants. These plants were spindling and very slow in establishing themselves and did not attain the stockiness and size of those in other rows.

The weight of the yield of each row was taken at harvest to quarter pound accuracy. There was no noticeable difference in the comparative amounts of large and small tubers in the different rows. The yields by rows are given in Table II.

The yields of the plots from cut seed were compared in each replication with the nearest check as well as with the average of the yields of all the check plots. The significance of the differences was determined by the method suggested by Student.* Table II shows that when compared with the average yield of the six nearest checks, the average yield of any six plots cut at the same time, is less. When a like comparison is made between the average yield of each group of six similarly treated plots and the average yield of all the checks, there are two cases in which the differences are in favor of the cut seed, namely rows nine and ten. In the other 10 treatments the differences are negative and significant, with the exception of row four. In this case the odds are only 3 to 1 that the difference is significant. In the other cases the probabilities range from odds of 900 or more to 1, to 20 to 1. In general, longer storage periods gave greater differences in yield. Both methods of comparison indicate that cut seed stored for any length of time before planting reduces the yield, but more data should be obtained since the results of this test are not entirely consistent.

*Student—"The Probable Error of a Mean" in Biometrika 6:1-25 1908.

TABLE II.

Comparison of Potato Yields from Treated and Untreated Tubers

Row—	Check	1	2	3	4	Check	5	6	7	8	Check	9	10	11	12	Check
Block Number 1	35.25	10.00	13.50	16.50	26.25	23.25	15.00	20.00	11.25	14.25	34.75	28.50	25.50	21.25	16.25	13.50
Block Number 2	13.50	13.25	21.50	17.50	19.75	24.00	18.00	19.50	21.00	21.50	27.00	35.25	38.75	23.00	25.50	32.75
Block Number 3	32.75	13.75	28.00	31.50	31.50	31.00	24.75	30.50	24.25	23.25	38.25	35.25	35.00	29.50	29.75	39.25
Block Series 4	23.25	9.00	15.50	21.00	22.75	27.25	15.25	14.50	14.25	19.25	20.75	21.25	23.50	22.25	21.25	17.75
Block Series 5	17.75	11.50	14.50	23.50	25.75	23.75	15.75	11.00	23.25	20.00	21.75	24.25	20.00	20.25	19.75	24.25
Block Series 6	24.25	14.00	18.00	19.50	27.00	25.75	13.50	14.00	23.50	28.25	31.50	28.75	24.50	21.50	20.75	26.75
Total of Differences Between	.....	check and 1	check and 2	3 and check	4 and check	.....	check and 5	check and 6	7 and check	8 and check	.....	check and 9	check and 10	11 and check	12 and check	.....
	.....	75.50	36.00	25.70	2.00	.....	52.90	45.70	56.50	47.60	.....	0.80	6.80	16.60	21.00	.....
Mean of Differences	.....	12.58	6.00	4.28	0.33	.....	8.82	7.62	9.42	7.93	.....	0.13	1.13	2.77	3.50	.....
Standard Deviation	.....	8.17	8.74	3.00	2.97	.....	2.55	5.00	7.75	7.24	.....	4.69	6.94	6.74	4.94	.....
Significance of Difference with average of checks, probability, odds to 1	.....	b	111	20	3	.....	768	55	64	112	.....	7	3	33	43	.....
Significance of Difference with nearest check, probability, odds to 1	....	108	11	83	2	..	3332	103	62	35	....	a	3	5	12	.....

a=Value of Z is less than any Z value recorded in table given by Student.
b=Value of Z is more than any Z value recorded in table given by Student.

The Effect of Certain Nitrogenous Fertilizers on the Yield and Quality of Spinach

By T. C. Johnson and H. H. Zimmerley, *Virginia Truck Experiment Station, Norfolk, Va.*

IN the Norfolk, Virginia, trucking area, the general practice in spinach fertilization is to make frequent applications of plant food materials to the growing crop. The fertilizer is applied broadcast upon the spinach beds at the rate of from 300 to 500 pounds per acre at each application. The total amount of materials used varies from 800 to 2000 pounds per acre depending upon the season of the year in which the crop is growing, the amount and frequency of rainfall, and the condition of soil fertility. When the spinach plants are small the areas between the rows are cultivated with a wheel hoe in order to mix the fertilizer with the soil, but during the later periods of growth the size of the plants renders cultivation impracticable and the plant food materials become accessible to the spinach roots only when they are washed into the soil by rainfall.

One of the problems which is presented in connection with this method of fertilization is the effect on growth as influenced by the use of nitrogenous materials of a different degree of availability. Since plant food is applied not only during the warm fall months, but also in the winter and early spring when the activity of the nitrifying bacteria is low, the seasonal factor must also be considered.

In the fall of 1920, experiments were started to determine the value of organic nitrogen as compared with the nitrate form when used in a complete fertilizer for spinach during the moderate fall, and also during the colder winter months.

In the experiments conducted during the fall of 1920 and winter of 1920-21, each plat contained two beds 630 feet long and 5 feet wide with four rows of spinach on each bed. The soil was a Norfolk fine sandy loam. Seed for the fall crop was sown September 12, and on October 14 the plants were thinned to stand 4 inches apart in the row.

Three fertilizer mixtures, each containing 9 per cent ammonia, 8 per cent phosphoric acid, and 3 per cent potash, but differing in the sources of nitrogen, were used. In one mixture nitrate of soda (18.5 per cent ammonia), in another animal tankage (11 per cent ammonia), and in a third, one-half nitrate of soda and one-half animal tankage, furnished the nitrogen. The experimental plats were divided into two series. In the first series each of the three mixtures was used at the rate of 1600 pounds per acre, applied in four applications of 400 pounds each, and in the second series 1600 pounds per acre in two applications of 800 pounds each. Plats in series No. 1 were treated on October 15, 29, November 13, and 17, and in series No. 2 on October 15, and November 6. Duplicate plats of each treatment were used.

The winter crop was sown on October 7 and on November 8 and 9 the plants were thinned to stand four inches apart in the row. The size and arrangements of plats, and methods of treatment, were the same as used in the experiments on the fall crop. Plats in series No. 1 were fertilized on November 10, December 16, January 15, and February 16, and in series No. 2, on November 10, and January 30. The effect on growth as measured by the weight of marketable spinach secured at the time of harvest is given in Table No. 1.

TABLE NO. I.

Yield of Marketable Spinach Secured by the Use of Nitrogen from Different Sources During the Fall of 1922 and Winter of 1920-21

	Fall Crop Harvested — December 8, 1920		Winter Crop Harvested — March 29, 1921	
Source of Nitrogen	Series No. 1 1600 pounds 9-8-3 applied in four applications. Average pounds marketable spinach per acre.	Series No. 2 1600 pounds 9-8-3 applied in two applications. Average pounds marketable spinach per acre.	Series No. 1 1600 pounds 9-8-3 applied in four applications. Average pounds marketable spinach per acre.	Series No. 2 1600 pounds 9-8-3 applied in two applications. Average pounds marketable spinach per acre.
Nitrate of Soda	9828	8208	8933	8100
Tankage	8218	9618	None	1600
One-half Tankage ..... One-half Nitrate of soda	9534	8596	6166	4033

At the harvest of December 8, the plats which received four applications with nitrate of soda as the source of nitrogen, gave the highest yield and exceeded that obtained on the tankage plats by 1610 pounds of marketable spinach per acre. Where one-half nitrate and one-half tankage furnished the nitrogen the yield was only slightly less than where nitrate of soda was the only source.

Where the materials were applied in two applications, tankage as the source of ammonia gave a higher yield than where nitrate of soda, or a mixture of tankage and nitrate of soda, was used. The large amounts of tankage applied when the spinach was small and the fertilizer could be well mixed with the soil, were rendered more quickly available by the action of the ammonifying and the nitrifying bacteria than occurred in series No. 1 where smaller and more frequent applications were made. The plats on which nitrate of soda alone as the source of ammonia was used produced the lowest yield where heavy infrequent applications were given. During the period between the first and second treatments in series No. 2 the precipitation was 5.6 inches, and it is likely that much

of the nitrate nitrogen was lost in the drainage water. Where the more frequent applications were made the loss of nitrogen was soon replaced without interference to plant growth. There appeared to be very little difference in the quality of the product from the differently treated plats.

The results obtained on March 29, when the winter grown crop was harvested, were somewhat different from those obtained in the fall. The nitrate of soda plats in both series gave the highest yields. In series No. 1 the areas where tankage alone furnished the nitrogen produced no marketable spinach. The plants were distinctly stunted in growth, reddish brown in color, and unfit for market. In series No. 2, where the large fractional applications were made, the growth was somewhat better but only 1600 pounds of marketable spinach per acre were secured as compared with 8100 pounds on the nitrate of soda plats. Where only one-half of the nitrogen was furnished by nitrate of soda the yields were 2767 pounds per acre less in series No. 1 and 4067 pounds less in series No. 2 than were obtained on the corresponding areas where the nitrate of soda was the only source of nitrogen.

The high yields obtained on the plats treated with nitrate of soda show that considerable growth took place even during the winter months at rather low mean temperature (7° to 9°C) where an abundance of nitrate nitrogen was present. The marked difference between the yields secured on the tankage plats in the fall as compared with those obtained when the crop was grown during the winter months, may be attributed to the effect of temperature on the rate of ammonification and nitrification of the organic nitrogen since a deficient supply of nitrates was apparently the cause of the slow growth of the spinach during the winter months where nitrogen was applied in the organic form.

Russel[1] found that at a storage temperature of 7° to 12°C the ammonia and nitrate increased from 17 parts to 22 parts per million of dry soil in a 50 day period, while at a 20°C the increase was from 17 parts to 30 parts in the same length of time. At this higher temperature the nitrification was 260 per cent greater than occurred at a temperature of 7° to 12°C.

The mean temperatures recorded for the time from the first application of fertilizer to date of harvest were as follows:

Winter Crop: November 10 to 30, 9°C; December 7°C; January 7°C; February 8°C; March 1 to 29, 15°C.

Fall Crop: October 15 to 31, 18°C; November 16°C; December 1 to 7, 6°C.

During the months of October and November, the period at which maximum growth occurred, the mean temperature did not fall below 16°C. This was sufficiently high to permit fairly rapid action by the organisms responsible for ammonification and nitrification. The mean temperatures during the period of winter crop production did not exceed 9°C, which was too low for ammonification and nitrification to proceed with sufficient rapidity to maintain rapid plant growth.

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[1]Russel, E. J., Soil Conditions and Plant Growth, p. 165.

The relatively high mean 15°C. for March was conducive to a renewal of bacterial activity, but occurred too near the date of harvest to produce available nitrogen for that crop. The exceptionally high yield for the tankage plats in series No. 2 of the fall crop, as compared with that of series No. 1 may be, in part at least, attributed to a higher rate of ammonification during the latter part of October when the mean temperature was 18°C. At the beginning of this period (October 15) the plats in series No. 2 received twice the amount of tankage as those in series No. 1, and it is probable that the production of nitrate was correspondingly higher where the larger amounts of materials were exposed to bacterial action at a favorable temperature. Series No. 1 plats received most of their fertilizer materials when low temperatures occurred. The fact that the tankage plats in series No. 2 of the winter crop averaged 1600 pounds of marketable spinach per acre as compared with none on those of series No. 1, indicates a recurrence of this condition. The higher yields were produced where the larger amounts of tankage were applied in November during a period of slightly higher temperature than occurred later.

TABLE NO. II.

Yield of Marketable Spinach Secured by the Use of Nitrogen from Different Sources in the Winter of 1921-22 and Fall of 1922.

Source of Nitrogen in 9-8-3 Fertilizer.	Fall Crop Harvested — December 6, 1922. Average pounds marketable spinach per acre.	Winter Crop Harvested — March 21, 1922. Average pounds marketable spinach per acre.
Nitrate of Soda	6568	10943
One-half Nitrate of Soda. One-half Tankage	4976	9942
Sulphate of Ammonia	6724	10104
One-half Sulphate of Ammonia One-half Tankage	5257	7806
One-third Nitrate of Soda One-third Sulphate of Ammonia One-third Tankage	5460	9927

In 1921 certain modifications were made in the plan of the experiment. The use of tankage alone as a source of nitrogen was discontinued and sulphate of ammonia alone, and in combination with tankage, and with tankage and nitrate of soda, was included in the experiments conducted in the winter of 1921-22 and the autumn of 1922.

Each plat contained two beds, 280 feet in length and 5 feet wide with four rows of spinach to each bed. In 1921, the seed was sown on October 7 and the fertilizers applied on November 18, December 13, January 14, and February 15, 1922, and the crop harvested on March 21, 1922. In 1922 the spinach was planted

on September 4, fertilized on October 14 and 28, and harvested on December 6. A period of drouth made additional applications during November inadvisable as that applied on October 28 remained on the ground mostly undissolved until November 16 when .5 inch of rain fell. The yields obtained are given in Table No. II.

The mean temperatures recorded by months from the time the fertilizers were applied until the crop was harvested are as follows:

Fall Crop, 1922: Oct. 14 to 31, 15°C; Nov. 10°C; Dec. 1 to 6, 10°C.

Winter Crop, 1921-22: Nov. 10 to 30, 13°C; Dec. 6°C; Jan. 5°C; Feb. 7°C.; March 1 to 21, 9°C.

Where one-half tankage was used with nitrate of soda as the source of nitrogen in the fall crop, the yield was reduced 1592 pounds per acre, and with sulphate of ammonia, 1470 pounds. Where the nitrogen was furnished by only one-third tankage in combination with nitrate of soda and sulphate of ammonia, greater yields resulted than when tankage supplied one-half of the nitrogen, but lower than where either nitrate of soda or sulphate of ammonia was the only source of nitrogen.

The slower growth and resulting low yields where the tankage furnished one-half of the nitrogen in the fall crop of 1922, as compared with the results obtained at the same season of the year in 1920, may be attributed to the lower temperatures and less rainfall in 1922. From October 14 to December 6, 1920, the precipitation was 6.14 inches as compared with only 1.9 inches for the same period in 1922. The amount of moisture present in the soil may not have affected the rate of ammonification, but lack of rainfall prevented the available nitrogen formed from the tankage near the surface of the soil from being washed to a lower level where it would have been accessible to the roots of the plants.

That nitrification from the ammonia to the nitrate form is more rapid at low temperatures than is the change from the organic to the nitrate form, is shown by the higher yields produced by sulphate of ammonia alone, as compared with one-half sulphate of ammonia, and one-half tankage, as a scource of nitrogen. In the winter crop the plats where sulphate of ammonia furnished the nitrogen, exceeded the yields of those where one-half sulphate of ammonia and one-half tankage were used, by 2298 pounds of spinach per acre.

In the fall of 1922, the comparative yields obtained on the nitrate and on the sulphate of ammonia plats, both where these materials were used alone, or in combination with tankage as a scource of ammonia, indicate that nitrification of the ammonia form was sufficiently rapid for optimum growth at mean temperatures of 10 to 15°C.

That the nitrification was probably less complete during the winter months when the mean temperature was from 5°C to 9°C, is indicated by the fact that the ammonia form gave lower yields than the nitrate, especially where each of these was used in combination with tankage.

The fact that in the winter crop of 1921-22, one-half nitrate

and one-half tankage, and also sulphate of ammonia alone, gave yields almost equal to those obtained on the plats where nitrate of soda supplied the nitrogen, indicates that the amount of nitrogen applied on the nitrate of soda plats was greater than could be utilized by the crop.

The color of the spinach plants on the sulphate of ammonia plats was a much darker green than occurred where either nitrate of soda, or tankage, had been used. This difference between the color of the foliage on the different plats was so distinct as to be discernable at a distance of several hundred yards.

A Comparison of Cultural Methods for Vegetable Crops

By J. B. Keil, *Agricultural College, Durham, N. H.*

THE success attending the efforts of many amateur and professional gardeners through following this, that, or the other method of culture for vegetable crops, leads the trained observer to the conclusion that the last word on cultural methods will not be written for some time to come. It is also reasonable to admit that some of the remarkable old-fashioned gardens we have known, which were handled according to methods prevailing long before experiment stations were abroad in the land, owed their excellence not entirely to the condition of the soil.

It is well to pause occasionally, and consider, from the standpoint of fundamentals the progress we are making, and determine whether possibly we are omitting an essential point here or there that may have been obscured by our zeal in the search for new things.

Personal contact with an experiment in cultural methods for truck crops has furnished the material for this paper. Three plots of garden land are used, upon each of which are planted tomatoes, sweet corn, cabbage, and beans. A rotation is followed, in which the location of each crop is changed on the plots each year.

The plan originally included three treatments—mulch, irrigation, and ordinary cultivation. Various circumstances interfered with the use of the irrigation system, so that this treatment has not been given. The comparisons are, therefore, limited to mulch, cultivation, and the addition in 1922 of a plot on which "scraping" was practiced.

The soil is a moderately heavy clay loam, rather retentive of moisture, and is easily compacted if worked when too wet. It has been well manured, but is probably not as fertile as the average market-gardener's land. The experiment was begun in 1919, but records were not taken until 1920.

In 1920, wet weather prevailed during the entire growing season. Weed control was very difficult on cultivated areas, but only a small amount of hand weeding was necessary on the mulched

plot. A remarkable difference in the progress of tomato leaf-spot and bean anthracnose was noted in connection with the mulched plot. The leaf-spot was much retarded in its progress from lower to higher leaves on the tomatoes, and the anthracnose was almost entirely localized to the hills of beans infected from the seed planted. This seems to be directly traceable to the fact that spores were washed from the infected leaves to the mulch, and were not returned to healthy plants by the splashing of rain, as was the case over the cultivated area.

The growing season of 1921 was a very favorable one, and rainfall was well distributed throughout the season. The season of 1922 was marked by unusually dry conditions which prevailed during the months of August, September, and October. The low nitrogen content of the soil in the mulched plot as shown in the table, was no doubt due to the fact that the very light rains in August did not penetrate the mulch, and nitrification was at low ebb.

The experiment has been in progress during three distinct types of seasons and the averages given as results of mulching and cultivation, seem to represent a fair trial of the methods of culture. The addition of a plot on which surface scraping only sufficient to control weeds was given, brought this method of treatment into the experiment under extreme conditions of drought, in which one would naturally expect a more thorough stirring of the soil to give better results.

The figures given in the following table represent yields of ripe tomatoes, mature cabbage, corn in good condition for table use, and beans in the snap-pod stage for one year, and as dry seeds for two years. The hills or plants were spaced 2 x 3 feet. Tomatoes were pruned to one stem and trained to stakes. The corn was planted liberally and thinned to two plants per hill. Cabbage plants were set out from cold-frame plant-beds. Beans averaged about 3 plants per hill. The mulch material consisted of spoiled hay in 1920, wheat straw in 1921, and grass clippings from the roadways in 1922. The mulch was applied when the plants were well started into growth so that it could be placed close to the plants and fully cover the soil.

Yields of Vegetable Crops under Different Methods of Culture
(In pounds per plant or hill)

	Average for	Mulched	Cultivated	Scraped
Tomatoes				(1 Year)
Bonny Best	3 years	6.26	6.48	6.03
Greater Baltimore	2 years	7.56	6.32	6.85
Sweet Corn				
Evergreen	3 years	0.91	0.87	0.81
Cabbage				
All Seasons	2 years	3.56	3.14	4.74
Beans, (Snap Pods)				
Bountiful	1 year	1.00	1.15	....

Beans, (Dry Seed) Henderson's Bush Lima	2 years	0.218	0.187	0.185

Determinations of moisture and nitrogen, 1922	Average for	Mulched	Cultivated	Scraped
Moisture—Percent	July	22.43	21.55	19.98
	August	14.78	14.77	14.48
	September	11.81	11.01	11.50
Nitrate Nitrogen—Parts per million	July	20.71	18.08	14.61
	August	4.93	15.48	12.31
	September	4.94	7.68	10.12

We may deduce from these results that on this land mulching is at least as good as cultivation, and that scraping merely to control weeds has given surprisingly good results under conditions which one would consider very unfavorable for such a practice.

A general consideration of this experiment, and others conducted elsewhere, would indicate that a modification of cultural practices with respect to certain crops and soil types might be made, with desirable results in several directions.

Where mulch material is available that is otherwise of little value, some vegetable crops can be produced with as good yield and less labor during the busiest part of the season, as by following the usual methods of cultivation. The harvested products are clean, and in wet weather, conditions under foot are much better with a mulch on the soil. Also some plant diseases are more easily controlled.

That deep cultivation for vegetables is not necessary and often not desirable, is also brought out by the fact that good results are obtained in small gardens where only shallow cultivation with hand implements is given. Many of the cultivations given with wheel-hoes in market-gardens amount to little more than scraping.

We may also venture the assertion that the degree of aeration of the soil as affected by deep cultivation, is not necessary and no doubt harmful, since mulching as compared with cultivation, certainly interferes with aeration, but with no detriment to the growing crop.

We should also include in this consideration the compacting of the soil below the cultivated layer by heavy implements, or by the trampling of draft-animals. In some seasons this part of the soil is reduced to a condition of density which exceeds that of unplowed soil, and cannot be favorable to the spread of plant root-systems.

Another point of interest is that of soil temperature, which is considerably modified under a mulch. It should be possible to reduce the soil temperature to a point below the optimum for some of the pathogenic soil-infesting organisms during ordinary seasons, and greatly facilitate disease-control measures, or possibly to make some of them unnecessary.

The home gardener with only a small area under cultivation, and perhaps a limited amount of time at his disposal, could also make use of mulch material, which might consist of lawn clippings or leaves from shade trees, if these materials are gathered when

available. An appreciable saving in labor is certain to be effected, once the mulch has been applied, and when the gardener chooses to take a vacation in mid-summer the garden is not so much in need of attention during his absence.

When one considers the diversity of soil treatments as practiced by successful gardeners, it is easy to arrive at the conclusion that the ingenuity of the gardener in adapting practices to conditions usually proves to be a large asset in the business. On the other hand, when one considers the diversity of conditions under which plants are successfully grown, from the friable untrodden compost of a sub-irrigated greenhouse bed to the rain-beaten and seemingly intractable clay loam of some farms, it is also easy to realize that Nature's ways cannot be reduced to a set of rules.

A Summary of Twenty Years Work with Sweet Potatoes

By J. H. Beattie, *United States Department of Agriculture, Washington, D. C.*

An important step in bringing order out of the confusion which has always existed in sweet potato nomenclature, was made when F. J. Tyler, using the variety collection maintained in the Bureau of Plant Industry, who worked out the basis of a key for the identification of sweet potato varieties. His work was done from 1902 to 1906 and served as a basis for later and more complete work by other investigators. During the progress of these studies material was secured from various sources, an effort being made to study all the supposed American varieties in order to recognize various sorts under different names. Between two and three hundred supposed varieties were grown and the duplicates eliminated. By taking into account such differences as the character of the foliage, stems purple or green, length of petioles, size and length of vines, size and shape of the potatoes, and the color of the flesh, it was found possible to group the 40 varieties remaining after duplicates had been eliminated, into seven groups distinguished from each other by definite botanical characters.

The key is being given herewith, but for a complete discussion reference is made to Departmental Bulletin 1021 entitled "Group Classification and Varietal Description of American Varieties of Sweet Potatoes."

Key to the Groups and Varieties Included in Each

I. Leaves deeply lobed or parted—1 and 2.

(1) Leaves with purple stain at the base of leaf blades—*Ticotea Group.*
Varieties included: Ticotea, Koali.

(2) Leaves without purple stain at the base of the leaf blades—*Belmont Group.*

Varieties included: Belmont, Eclipse Sugar "Yam," Vineless Pumpkin "Yam," Old Time "Yam," Yellow "Yam," White Sealy, Gros Grandia, Bunch Candy "Yam."

II. Leaves not deeply lobed or parted—1 and 2.

(1) Leaves with purple stain at the base of the leaf blade—A and B.

(A) Stems purple or greenish with decided tinge—*Spanish Group.*

Varieties included: Pierson, Yellow Strasburg, Yellow Spanish, Triumph, Red Bermuda, Red Brazil, Porto Rico, Key West "Yam," Creola, Red Spanish, Purple "Yam," or Nigger Choker, Dahomey.

(B) Stems green—a and b.

(a) Leaves entire to slightly shouldered; roots white—*Shanghai Group.*

Varieties included: Shanghai, Minnet "Yam."

(b) Leaves toothed with 6 to 10 low marginal teeth, or entire: roots salmon or yellow tinged with salmon—*Florida Group.*

Varieties included: Florida, General Grant Vineless, Nancy Hall.

(2) Leaves without purple stain at the base of the blade or with very faint stain—A and B.

(A) Stems purple—*Southern Queen Group.*

Varieties included: White "Yam," Southern Queen.

(B) Stems green—a and b.

(a) Stems medium to large in size; roots fusiform, yellow tinged with salmon, with light yellow veins—*Pumpkin Group.*

Varieties included: Pumpkin "Yam", Norton, Dooley, White Gilke.

(b) Stem slender; roots russet yellow or red, ovoid to fusiform—*Jersey Group.*

Varieties included: Japan Brown, Red Jersey, Vineland Bush, Big Stem Jersey, Philipili, Yellow Jersey, Gold Skin.

It is felt that the key is based on sound characters as it works well in field practice. It is desirable that the studies be continued, as other distinct varieties may not have come under the observation of the investigators, and we would appreciate help from the members of the Society in securing seed stock of various sorts, so that a growing test can be made to ascertain if they possess true varietal characters, and if not to determine their relationship to other sorts. It is extremely desirable that we learn the large number of names now applied to recognized varieties as this will be of material aid in putting sweet potato nomenclature on a sound basis.

Whitney and Seedlings from Whitney Crosses

By C. S. Crandall, *University of Illinois, Urbana, Ill.*

THE earliest printed reference to Whitney appears to be that by Dr. J. A. Warder in April, 1869, in volume 5 of Tilton's "Journal of Horticulture" under the title: "Hardy Apples—Siberians." After reference to Hyslop, Transcendent, Montreal Beauty, Large Red, and Large Yellow, Dr. Warder says, "Among those of more recent origin, I propose to introduce some of those selected from a large number of seedlings grown by A. R. Whitney of Franklin Grove, Illinois, and the 'Winter Crabs' introduced to the public by Charles Andrews of Marengo in the northern part of that state, some of which were exhibited in good condition at the Freeport meeting in February, 1868."

A recent letter from Mr. N. A. Whitney, son of A. R. Whitney, states that Whitney is a seedling of Red Siberian Crab. A quantity of seedlings were grown and used as stocks for root grafting. Some of the scions failed, but the stocks grew. As some of these stocks appeared promising, the best were transplanted and numbered.

Dr. Warder, in the article cited above, describes fruits from numbers 14, 20, and 24. Fruit of No. 20 is described as follows: "Fruit ovate, larger than Transcendent; surface smooth, yellow, striped, and, when exposed to the sun, two-thirds covered with red; flesh yellow, crisp, juicy; quality pretty good for eating, fine for early tarts. Ripens 14 days before the large yellow."

At the Boston meeting of the American Pomological Society in 1873, Mr. Arthur Bryant refers to Whitney No. 20 as of "very superior quality and large size for that species of fruit, and well worthy of notice." At the Chicago meeting of the Society in 1875, Mr. O. B. Gabusha in reporting for Illinois, writing of crabs says, "Among these the Marengo and Whitney No. 20 are generally regarded as best."

Whitney was first admitted to the American Pomological Society catalogue at the Boston meeting in 1881.

When the present line of apple breeding began at the Illinois station in 1908 Whitney was represented in the plantations by 41 trees. These trees were mature and had been fruiting at least since 1901 and were probably about 17 years old in 1908. When I first knew these trees, 20 years ago, they were remarkable for similarity, symmetry, vigor, and productiveness; in form they were erect, the branches ascending with little departure from the perpendicular. Six of these trees still remain and as measured last month they average 25 feet 8 inches in height, 26 feet 6 inches in spread, and 12.66 inches in diameter. Under the weight of heavy crops of fruit the branches have been bent outwards; they are still ascending, but at greater departures from the perpendicular. The broadest part is near the top, but symmetry is retained.

Whitney has been used as the female parent in 8 crosses with 3 orchard varieties, 4 crab forms, and 1 hybrid, as pollen parents. Four of the crosses were on trees in the orchard, and four on potted trees on dwarf stocks in the greenhouse. The earliest crosses were made in the orchard in 1911; there were two of them and each may be briefly examined. This first cross was by Yellow Siberian Crab. In this cross two presumably closely related forms are combined; the Whitney, a seedling of Red Siberian Crab and the pollen parent Yellow Siberian Crab. It seems probable that both forms are descended from the European Malus prunifolia, rather then from Malus baccata; but ancestors of both forms have undoubtedly hybridized, though where, when, or with what, no one knows; certainly there is no evidence available to warrant considering either of the forms, genetically, as anything but varieties of unknown origin.

The tree from which pollen for this cross was taken is of the same age as the tree of Whitney used as the female parent. This tree is still standing, a healthy, vigorous, wide-spreading tree having measurements as follows: height 29 feet 4 inches, spread, 43 feet 2 inches, and diameter 16.8 inches. Pollen was applied to 93 emasculated Whitney buds, May 6, 1911, and 28 mature fruits were harvested August 10. The fruits represent 30.11 per cent of the pollinations; they contained 157 plump seeds, an average of 5.6 to each fruit. Germinations numbered 90 or 57.32 per cent; that there was absence of excessively weak seedlings is evidenced by the fact that the full number, 90 seedlings, was transferred to nursery. That there were some weak seedlings is shown by the record of the first year, during which 19 or 21 per cent died; there were further losses of 7 in the second year, and 3 in the third, but this ended losses that could be ascribed to inherent weakness. Loss of two trees in the fifth year and one in the ninth, were due to attacks by blight.

Casual examination of the 57 living trees as they stand in orchard gives the impression of regularity, symmetry and beauty, but when measured and examined critically, considerable differences are brought out. The trees range in height from 8 feet 2 inches to 17 feet 8 inches, with an average of 14 feet 2 inches; in spread from 5 to 19 feet, with an average of 11 feet; in diameter from 1.5 to 6.9 inches, with an average of 4.69 inches.

In habit the trees are either erect or narrowly ascending; in every case the habit of Whitney with no approach to the broad spreading habit of the male parent. Foliage is dense and dark green on most trees. Roughly classified on the basis of size of leaf, 38 have large leaves, 15 have leaves of ordinary size, and four have small leaves; that is, leaves that are distinctly shorter and narrower than are leaves on other trees of the group; these trees appear more open and less vigorous than do the others. All trees in the group may rightly be classed as vigorous, but there is absence of those evidences of excessive vigor that characterize some groups of hybrid seedlings, notably those from the crosses Tolman X Toringo, Tolman X Malus atrosanguinea, Rome X Malus floribunda, and Rome X Malus atrosanguinea.

Of the 57 trees, at 11 years of age, 16 or about 28 per cent have borne fruit; one fruited in 1918 at 7 years of age, two fruited in 1919, six in 1921, and seven in 1922. As to season, one tree matured fruits in late July, seven in early August, seven in late August, and one in early September. In color all fruits closely resemble Whitney. In form, eight are roundish-oblate, four are distinctly round, and four are oblong-conical. Flavor of one is acid, of 13 mildly subacid, and two are distinctly sweet.

The average weight, considering all fruits examined from the 16 trees, is 31 grams; the vertical diameter 35 mm. and the transverse diameter 41mm. Weight and dimensions are a little below, but very near the true intermediate between the parents. Seed production in fruits from these hybrids averaged 5.91 seeds to each fruit; this is slightly below the average of the parent plants. Of the 57 trees in the group 90 per cent grade as "good," 5 per cent as "fair," and 5 per cent as "poor."

The second cross of 1911 is one in which pollen of 838, a form of Malus prunifolia, was used. Probably no species of the genus Malus, with the possible exception of that mythical, or at least uncertain species, Malus Malus, exists under a greater number of forms, or is in greater confusion as to nomenclature, than is Malus prunifolia. Koch (Dendrology 1869) gives the habitat of the species as North China, Tartary and Southern Siberia. He refers to a number of forms that differ in size and habit of tree, in size and pubescence of leaves, and in size and coloring of fruit.

Regel in his Russian Dendrology, St. Petersburg, 1874, describes the species, refers to the persistent calyx lobes and says that this characteristic distinguishes Pyrus prunifolia from Pyrus baccata. He names 10 varieties.

The station collection of Malus has contained seven forms of the species prunifolia, five of which have fruited and have been used in crosses with various orchard varieties. The form 838, used in this cross, develops a tree of medium size, of erect habit, rather large elliptical, long-ovate or oblong light green leaves that are heavily pubescent early in the season, but become nearly glabrous by fall. The fruit is yellowish green, with a reddish-brown blush on the side exposed to the sun. The average of 100 fruits weighs 10 grams, has a vertical diameter of 24 mm. and a transverse diameter of 27 mm. Seeds average 6.46 to each fruit. That this form has at some time hybridized with a form of Malus baccata is indicated by the fact that calyx lobes are not all persistent. Of 9112 fruits examined, 258 or 2.83 per cent have calyx lobes regularly deciduous. A tree of 838 Malus prunifolia, now 15 years old from root graft, is 17 feet high, 11 feet in spread, and has a diameter of 4.4 inches.

From pollination of 48 Whitney flowers by pollen of this form of Malus prunifolia, 25 fruits were matured, a success percentage of 52.08. The fruits contained 154 seeds, an average of 6.16 and 101 or 65.58 per cent germinated. There are now living, at 11 years of age, 60 seedlings; the loss of 41 occurred mainly in the early years and was due to constitutional weakness of the seedlings.

Seedlings of this group are of the same age and stand in rows

contiguous to those occupied by seedlings of the cross Whitney X Yellow Siberian Crab. Looking along the rows, trees of the two groups appear much alike, but it is apparent that trees of the prunifolia group are narrower, more strictly erect than are trees of the Yellow Siberian Crab cross and this impression is confirmed by measurement of individuals.

Average height of trees of the prunifolia group is slightly less than for the Yellow Siberian group; average spread is two feet less and average diameter of .81 inch less. While 17½ per cent of trees of the Yellow Siberian group are classed as strictly erect, more than 43 per cent of trees of the prunifolia group fall into this class.

Extremes in form are much more widely separated in the prunifolia group than in the Yellow Siberian group. It would seem reasonable to expect some spreading trees in the Yellow Siberian group because of the spreading habit of the male parent, but there are none; while in the prunifolia group, from a cross in which both parents are of erect habit, there are two trees of unmistakable spreading, almost straggling habit. Trees in this prunifolia group grade as 58 per cent "good," 30 per cent "fair," and 12 per cent "poor."

Trees of the prunifolia group are, apparently, more precocious than those of the other group, for 36 or 60 per cent. have borne fruit, while only 16 or 28 per cent of the Yellow Siberian group have fruited. The Yellow Siberian group, however, includes one tree that fruited in 1918 at 7 years, one year earlier than any tree of the prunifolia group. Fruiting of trees of the prunifolia group has been as follows: 1 tree in 1919, 16 trees in 1920, 15 trees in 1921, and 4 trees in 1922. Fruits from the 36 trees have an average weight of 17 grams, a vertical diameter of 30 mm. and transverse diameter of 32 mm. In the Yellow Siberian group weight and dimensions approximate the intermediate between parents, but in this prunfolia group weight and dimensions, while showing considerable increase over the prunifolia parent are still far below the true intermediate between parents. In color, fruits from the trees resemble those of Whitney; most fruits are highly colored, in many of them the bright red covers nearly the whole surface. In flavor, fruits from 17 trees are acid, from 18 trees subacid, and from one, sweet. In form, six have oblate fruits, 12 have round fruits, 10 have conical, and 8 oblong fruits. Nine trees matured fruits in late August, four in early Steptember, 21 in late September, and two in early October. Seed production is less than that of either parent, the average being 4.6 to each fruit.

The next cross in which Whitney is the female parent is the 1912 cross by Winter Rambo and this is the only orchard cross in which Whitney is mated with a recognized orchard variety. Fifty buds emasculated May 2 were pollinated May 6 and 26 mature fruits, representing 52 per cent of the pollinations were picked August 21. The fruits contained 121 seeds, an average of 4.65 to each fruit. Germinations numbered 61 or 50.41 per cent of the seeds planted. That there were many very weak seedlings is shown by the fact that only 43 lived to be planted in nursery, an

initial loss of 18 or 29½ per cent of the 61 germinated. There was further loss of 3 in the first year and one in the second, bringing the loss to 22 or about 36 per cent ascribed entirely to constitutional weakness. Losses that occurred later, 1 in the 6th year, 4 in the 8th, 1 in the 9th, and 2 in the 10th, a total of 7 were due to infestation by blight. At the end of the 10th year there are living 31 seedlings which grade as 28 "good," 2 "fair," and "1 poor."

Winter Rambo, the male parent in this cross, grows fairly upright in its early years, but soon becomes wide spreading. The tree from which pollen was taken in 1912 was at that time 18 years old; it was removed in 1915, but is well-remembered as a very wide-spreading tree. Young trees propagated from the original male parent in 1915, and now 9 years from graft, when compared with Whitney trees of equal age and with the hybrids at 9 years, show that the average hybrid dimensions stand very near midway between simiar dimensions for the parent trees.

Averages for the hybrids are, height 12½ feet, spread 7½ feet, and diameter 3.95 inches. But the hybrid trees have stronger resemblance to Whitney trees than to those of the male parent. Classified by form 19 are erect, 9 narrowly ascending, 2 broadly ascending and 1 spreading.

Of the 31 trees in this group 13 or approximately 42 per cent have fruited; one bore fruit in 1918, one in 1920, two in 1921, and nine in 1922. Ten have oblate fruits and three round fruits. Eleven bore subacid fruits and two sweet fruits. The season for seven is early August, for four, late August, and for two, mid-September.

In weight the average of 36 fruits from the 13 trees is 88 grams; this is 69 per cent heavier than the average of Whitney fruits, but 20 per cent smaller than fruit of Winter Rambo. In size and form the fruits suggest Winter Rambo rather than Whitney, but in color and flavor they are most like Whitney. Some of the fruits are recorded as highly colored and of excellent flavor and two are of sufficient excellence to warrant propagation for further trial. No cross involving a crab as one of the parents has given as promising fruits as those from the cross Whitney X Winter Rambo. Some of the seedlings, unfortunately, show a tendency to blight; seven of the strong growing, and therefore, better trees have been more or less deformed by necessary removal of blighted branches.

The next, and last, orchard cross in which Whitney appears as the female parent is that by 856 Malus prunifolia var. This form of Malus prunifolia is one of a number of seedlings grown at the Arnold Arboretum from a mixed lot of seeds collected by Dr. C. S. Sargent in Japan in 1892. From its characters it is determined as a form of Malus prunifolia, but that its parents had at some time hybridized with some form of Malus baccata, is indicated by the large proportion of fruits having the calyx lobes deciduous. Of 5270 fruits, examined particularly with reference to this character, 3048 or 57.83 per cent have persistent lobes and 2222 or 42.17 per cent have the lobes regularly deciduous.

This form is a vigorous, extremely erect tree with elliptical, ovate, or oblong dark green leaves; trunk dark brown tinged olive-green; twigs reddish-brown. Trees of this form of Malus prunifolia compared with Whitney trees of the same age are taller, have less spread and are of greater diameter. The fruit is small, bright yellow, round; the average of 50 fruits weighs 2.56 grams, is 16 mm. in vertical diameter, and the same in transverse diameter. Seed-production averages 5.64 to each fruit.

Pollination of 48 Whitney flowers yielded 26 fruits or 57.17 per cent of the pollinations successful. The fruits contained 151 seeds or 6.03 to each fruit; only 57 or 37.75 per cent germinated. Many seedlings were so weak they died before time to plant in nursery; this loss amounted to 27 or more than 47 per cent; one tree died during the first year, two in the second, one in the fifth, and three in the sixth; bringing the losses to 34 or about 60 per cent. The 23 trees remaining are now 10 years old; they grade as 15 "good," 6 "fair," and 2 "poor." In habit, 11 are erect, 11 ascending, and 1 spreading. The average of the 23 trees is 13 feet high, spread 8½ feet, and has a diameter of 4.49 inches.

Four of the trees bore fruit in 1918 at six years of age, two fruited in 1920, one in 1921, and three in 1922. The fruits from these 10 trees are uniform in one character, in that they all have the coloring of Whitney the female parent. In all other characters there is extreme variation, particularly in size; weights of fruits range between a minimum of 4.1 grams and a maximum of 41.85 grams with an average of 9.16 grams. Form of fruits from 6 trees is oblate, from 1 tree round, and from 3 trees oblong. In flavor, 4 trees have acid fruits, 3 subacid, and 3 sweet. Five mature fruits in late August, 3 in late September, and 2 in early October.

The four crosses considered are fairly uniform in percentages of successful pollinations, in seed content of crossed fruits, in seed germination, and in endurance of seedlings. The striking feature in all the crosses is the dominating influence of the female parent; this is evident in habit of growth of seedling trees, in form, size, and reduction of acidity in fruits, and, perhaps most of all, in the coloring of fruits. Two of the male parents have self-yellow fruits, one has fruits mostly yellow, but occasionally developing a dingy red blush, and the fourth pollen parent, Winter Rambo, has red of a dull and dingy shade. Of the 75 trees thus far fruited, the fruits all show bright red and in most it is developed as in Whitney; usually more or less striped on clear yellow, but in some fruits washed in areas that extend over most of the surface.

Greenhouse Crosses

Whitney was the mother parent in four crosses in the greenhouse, one of which that by Malus baccata maxima, in 1915 failed.

In 1917 Grimes pollen was used on three Whitney flowers and three fruits matured; these contained 22 seeds, 14 of which germinated. Two of these seedlings died in the fourth year and there are now living 12 seedlings, five years old, which are exhibiting the same habits of growth that characterized the groups of seedlings from older crosses.

The remaining first generation cross was by Oliver in 1918; here one pollination was made and one fruit matured; this fruit contained five seeds four of which germinated. The four seedlings are now in orchard, two are still whips and, of the two that have branched, one promises to be erect, the other somewhat spreading.

The one other cross in which Whitney was the female parent was one of 1919, in which pollen from a seedling of the 1911 cross Whitney x Yellow Siberian Crab was used. Ten pollinations were made, half of which were successful. The five fruits contained 28 seeds, 25 or 89.28 per cent of which germinated; four seedlings have died, and 21 have completed their first year in orchard. These seedlings possess reasonable vigor; they are mostly whips, but those that have thrown out branches are assuming the upright Whitney form.

Fruiting of these second generation seedlings will be anticipated with interest.

WHITNEY AS THE POLLEN PARENT.

Whitney pollen has been used on flowers of seven varieties and six crab-like forms of Malus. Of the seven crosses on varieties, those on Early Ripe, with 50 pollinations, and Summer Pound Royal with 48 pollinations failed entirely. The crosses maturing fruits were Melonen 46 pollinations, 12 fruits; Winesap 48 pollinations, 1 fruit; Tolman 48 pollinations, 10 fruits; Shackleford 50 pollinations, 1 fruit; and Fameuse 2 pollinations, 1 fruit. The last was a greenhouse cross, the others in orchard. Percentages of success range from 2 to 50 with an average of about 13, a low record.

The 12 fruits from the Melonen cross of 1912 contained 121 seeds, 65 per cent of which germinated and there are now living 47 seedlings, 10 years old; they represent approximately 60 per cent of the germinations.

Melonen is a Russian variety of erect habit, and with both parents of the cross having similiar upright form of growth, the expectation of erect progeny is fully realized. Of the 47 trees living at the end of the 10th year, 39 have erect branches, and 8 ascending branches. Average height is 13½ feet, spread 7 feet, and diameter 3.87 inches. Forty-two grade as "good," and five as "poor." These five are poor, not because of any inherent weakness or defect, but because attacked by blight, and removal of blighted terminal shoots has deformed them.

In this, the 10th year, 15 of the trees bore fruit which, in weight and size, averages between fruits of the two parents; larger and heavier than fruits of Whitney, but not equalling the Melonen fruit for which an average of 95 grams is recorded. The maximum weight of a hybrid fruit is 125 grams, the minimum 32 grams, and the average 66 grams. In form, four trees have oblate fruits, five have round fruits, and six have fruits that are roundish-conical. As to season, two matured fruits in early July, seven in late July, four in early August, and two in late August. Fruits from one tree are acid, from 13 trees subacid, and from one, sweet.

The prevailing color of Melonen fruits is yellow, with some fruits showing faint, broken stripes of light red. Fruits of the hybrids are all colored after the same pattern, namely, bright red blushed or striped on clear yellow, as in fruits of the male parent. The extent of the red over-color differs somewhat in different fruits, but is usually abundant and handsome. Many of the fruits are replicas of well-colored Whitney.

In 1914, 48 flowers of Winesap were pollinated by Whitney, but only one fruit matured. This fruit contained 9 seeds, 8 of which germinated, and at the end of the 8th year, 6 seedlings were living: one has the spreading form of Winesap, and 5 the erect or ascending form of Whitney. The average height is 10 feet 7 inches, spread 8 feet, and diameter 2.8 inches. These trees are healthy and vigorous, but none, have fruited.

Also in 1914, 48 flowers of Tolman pollinated by Whitney yielded 10 fruits with 80 seeds, 56 or 70 per cent of which germinated and 36 or 64 per cent of the seedlings produced are now living; the average height is 10 feet 3 inches, spread 5 feet 10 inches, and diameter 2.43 inches. Of this group of seedlings, 20 grade as "good," 12 as "fair," and 4 as "poor," 20 are erect and 16 have ascending branches, all approximating the form of Whitney the male parent. None have borne fruits.

Another cross in 1914 was that on Shackleford. Fifty flowers pollinated by Whitney gave one mature fruit containing 7 seeds, 5 of which germinated and 4 of the seedlings are living. These trees average 9 feet in height, 6½ feet in spread and have an average diameter of 2.53 inches. These seedlings are erect and healthy, but have not yet borne fruit.

The remaining cross of Whitney on an orchard variety is that made on Fameuse, in the greenhouse, in 1917. Here two flowers pollinated matured, one fruit having 7 seeds, 6 of which germinated. The six seedlings are now in orchard and are five years old. These trees were shifted under unfavorable circumstances last spring, and at that time were cut back and pruned to whips. They grew well during the season and five of them tend to assume the erect form like that of the male parent; one is distinctly spreading like the female parent.

Whitney Pollen on Flowers of Crab-forms.

Of six crosses attempted with Whitney pollen on crab-forms, two, a greenhouse cross of 1914 on Malus spectabilis and a 1915 greenhouse cross on Malus Ringo sublobata, failed in fruit-production.

Four of the crosses developed fruits; the first of these was a 1911 cross in orchard in which 48 flowers of Yellow Siberian Crab were pollinated by Whitney and matured 8 fruits containing 48 seeds, 36 or 75 per cent of which germinated. Of the seedlings produced 26 or 72.22 per cent are now living at 11 years of age. These trees have an average height of 13 feet 4 inches, an average spread of 9 feet, and an average diameter of 4.37 inches. Seven are strictly erect and 19 have branches narrowly ascending. In grade, 19 are "good," 6 "fair" and 1 "poor." They have the habit

of Whitney and are not distinguishable from that other group of 57 trees derived from the cross in which Whitney was the female parent and Yellow Siberian Crab the pollen parent.

Fruits have been described from 15 of the 26 trees. These fruits have an average weight of 28.48 grams, an average vertical diameter of 36 mm. and of transverse diameter 39 mm. Fruits from 6 trees are oblate, from 6 round, and from 3 oblong-conical. In flavor, 11 have subacid and 4 sweet fruits. In season, one tree matures fruits in late July, 11 in early August, and 3 in late August. One tree fruited in 1919 at 8 years, 11 fruited in 1921, and 3 in 1922. The fruits are in no way different from those of trees of the reciprocal group; all have the Whitney color bright red blushed or striped on clear yellow.

The other cross of 1911 was that in which 838 Malus prunifolia as the female parent had 17 flowers pollinated by Whitney pollen. Ten or 58.82 per cent of the pollinations were successful; a high degree of success, but the fruits averaged only 2.5 seeds each and only 20 per cent of the seeds germinated. Three of the 5 seedlings died the second year in nursery; the remaining two are now healthy, vigorous trees with an average height of 10¼ feet, an average spread of 5 feet, and diameter of 3.6 inches. Both have the form of the Whitney parent, but neither has fruited.

The next cross 19644 Malus microcarpa X Whitney was made in the greenhouse in 1914. Pollinations numbered 25 and 10 or 40 per cent were successful. The 10 fruits contained 57 seeds only 17 of which germinated; only 9 seedlings lived to be planted in nursery and 4 of these died during the first year. Of the 5 trees living, one was broken over and because of this injury is much shorter than the others; the four normal trees average 10 feet in height, 6 feet in spread, and 2.45 inches in diameter. These trees have the same upright habit of growth that has characterized progeny of other Whitney crosses.

The remaining cross on crab-like forms is one made in the greenhouse in 1915, using 19646 Malus Scheideckeri as the mother plant. Twelve pollinations matured 4 fruits which contained 7 seeds, only three of which germinated; one seedling died the first year. The two seedlings left are seven years old, average 6½ feet high, have a spread of 4½ feet and a diameter of 2 inches. Habit of growth is erect. One of the trees bore fruit this season; the average fruit is 2½ times the weight of that of the female parent, but must be multiplied by 6 to make it equal that of the male parent. This average fruit weight 8.67 grams, has a vertical diameter of 21 mm. and a transverse diameter of 28 mm; it is oblate in form, subacid, and colored as is fruit of the male parent.

Crossing for à Second Generation.

There is one other group of crosses in which Whitney was used as the male parent and first generation seedlings of some of the earlier Whitney crosses as female parents. This group, of course, aims at production of a second generation of seedlings, from controlled pollinations.

In the years 1918 to 1921, 17 such crosses were made on 13 trees representing five different parental combinations. Ten of the greenhouse crosses involving 38 pollinations on 8 trees of 5 parental combinations failed.

Of the 7 more or less successful crosses, three on three trees representing two parental combinations were on trees in orchard and four on three trees, of as many parental combinations, in greenhouse.

The orchard crosses of 1918 used three hybrids as female parents with results as follows:

	Flowers	Fruits	Per cent	Seeds	Germinated	Per cent	Living
2213-1-1 Whitney X 856 M. prunifolia	31	3	9.67	19	6	31.58	4
2161-2-2 Whitney X Winter Rambo ..	32	13	40.62	96	62	64.58	42
2224-2 Whitney X 856 M. prunifolia	53	10	18.86	41	24	58.53	9
Greenhouse crosses were as below, the first in 1920, others in 1921.							
2161-1-2 Whitney X Winter Rambo ...	6	2	33.33	15	11	73.33	9
(3) 1261-a-2 Whitney X Yellow Siberian Crab	23	2	8.70	1	1	100.00	1
2161-1-2 Whitney X Winter Rambo ...	10	4	40.00	30	18	60.00	15
2203-1-5 Whitney X 856 M. prunifolia	18	4	22.22	12	9	75.00	9

The three crosses made in 1918 are now represented in orchard by 55 second generation seedlings four years old. These trees are still small, but already indicate that they will develop on the same form lines followed by all first generation seedlings of these Whitney crosses.

The four crosses of 1920 and 1921 are represented by 34 second generation seedlings not yet out of the nursery stage.

It may also be mentioned that in the greenhouse in the spring of 1922, 11 first generation seedlings of Whitney crosses representing five parental combinations were used as mothers in crosses with Whitney. The 11 crosses made involved 142 pollinations. Three of the crosses with 23 pollinations failed; the other eight including 119 pollinations yielded 28 fruits from which 110 seeds were obtained. These seeds were recently planted.

Nutritive Conditions Associated with the Change of Sex in the Strawberry

By V. R. Gardner, *Agricultural College, East Lansing, Mich.*

To be printed as a research bulletin by the Missouri Agricultural Experiment Station.

Peach Breeding—A Summary of Results

By C. H. Connors, *Experiment Station, New Brunswick, N. J.*

A PRELIMINARY report of the results of our peach breeding work, following the first season of fruiting, was published in the proceedings of this society for 1919, (1). Since that time nearly all the trees have fruited, and, in view of the interest that has been displayed in this project it was felt that some further report should be made at this time.

Parent Varieties

The parent varieties reported in the earlier paper were Greensboro and Early Wheeler, homozygous white fleshed; Belle, heterozygous white fleshed; Elberta, Early Crawford and St. John, yellow fleshed. In addition to these, seedlings from the following parents have fruited: Homozygous White—Carman, Heterozygous white—Lola, Yellow—Arp, Slappey, Dewey.

Influence of Crossing Upon the Habit of Growth of the Tree.

The best tree habit for orchard purposes is the open, spreading type, such as is found in Greensboro, Carman and Lola. The least desirable, in that it is more difficult to prune, is the upright, dense topped type of Early Crawford. The most widely grown variety is Elberta and this is a blending of the two types, in other words, it may be characterized as upright-spreading.

In crosses between Greensboro (spreading type) and Early Crawford (upright type), the seedlings were all intermediate, none being the same as either parent, presenting the blended type of inheritance. Seedlings of Early Crawford, self-pollinated, were all upright. Seedlings of Carman and Lola were all spreading. The progeny from Elberta self-pollinated would give Mendelian ratios of 1-2-1 upright-intermediate-spreading, if so desired, but they actually present a quetelet curve when all of the variations are tabulated, with the mode at the habit of the parent. Seedling trees resulting from crosses between white and yellow varieties possessed vigor superior to that of the yellow parent and, frequently, of the white parent.

In breeding for orchard types, therefore, it is desirable to use as one parent a variety of either the spreading, or the intermediate type.

No true dwarfs have appeared among the progeny of these varieties, but Elberta self-pollinated has given several seedlings of the J. H. Hale, or semi-dwarf type. If enough seedlings of Elberta could be raised, dwarfs would probably appear, as a bud mutation appeared upon Elberta that is a true dwarf attaining a height of only 7 feet at 5 years of age. Open pollinated seedlings of this sport gave dwarfs and semi-dwarfs so that this is undoubtedly a recessive character.

Inheritance of Foliar Glands.

This was reported in the proceedings of this Society for last year so that there is no need to go into detail at this time. (2) Reniform glands are dominant over eglandular forms. Additional evidence was gathered during the past summer on the heterozygous nature of the globose glands and of the supsceptibility of the eglandular leaves to mildew.

Inheritance of Size of Blossoms.

While of little economic significance, this subject is interesting from a taxonomic point of view. The same fact holds true with blossoms as with several other gross, or taxonomic characters, that a blended type of inheritance obtains here, with, it appears, a slight dominance of the small bossom type.

Since the older systematists recognized only two types, large and small, it might be well again to differentiate. The large blossomed type have petals ranging from 13 mm. to 18 mm. wide and from 17 mm. to 20 mm. long. The gap from large to medium is definite. The medium sized blossoms have petals from 7 mm. to 9 mm. wide and from 9 mm. to 13 mm. long. The small blossomed type range in petal size from 5 mm. to 7 mm. wide by 7 mm. to 10 mm. long. It is at once apparent that there is an overlapping here, but the types can be distinguished by the shape of the petals, the medium being oval and the small somewhat spatulate.

In all cases studied, the large blossoms and small blossoms were homozygous, while the medium sized blossoms were heterozygous. Large crossed with small gave all medium and the mediums split up 1-2-1, large medium-small.

Sterility of Blossoms.

The peach is generally considered self-fertile. Close (1) and Wiggans (5) bagged blossoms of standard commercial sorts and found them self-fertile. In our own breeding operations, blossoms covered to exclude insect visitation set fruit to their own pollen. Nevertheless, sterility is present in the peach. Fletcher (4) reports the variety Susquehanna as having a tendency to self-sterility and it has been learned that the variety J. H. Hale is almost completely self-sterile.

Self-sterility in the case J. H. Hale is not self-incompatibility, but is due to lack of pollen production. The anthers appear to be a mass of protoplasm which dries up after the normal period of dehiscence.

This sterility of the anthers has appeared among the peach seedlings. It was not observed until after a number of the seedlings had been removed, but probably most of the sterile individuals remain, as they are very shy of bearing, depending upon cross pollination, and weather conditions during the blooming season are frequently unfavorable for insect work.

The percentages of sterile individuals is predicated on the assumption that all the sterile individuals remained at the time the observations were made. The percentage of sterile seedlings is as follows: Belle self pollinated, 5.7 per cent; Elberta self-polli-

nated, 7.5 per cent; Belle x Elberta, 1.5 per cent; Elberta x Belle, 2.2 per cent; Elberta x Greensboro, 2.7 per cent; Belle x Greensboro, 1.5 per cent.

The importance of this character is seen in the case of J. H. Hale, which will be discussed in another paper at a later session. And, sad to relate, three of the seedlings that were selected for extended trial proved to have this imperfection and had to be discarded.

Blooming Dates.

While peach varieties vary in blooming dates, the time of first blooming usually varies only about a week at the most between the earliest and latest blooming. But even this variation may prevent damage by frost. The blooming habit seems to be connected rather closely with irritability, or tendency to blossom bud development at a rapid rate during warm spells in winter.

The majority of seedlings bloom at practically the same season as the parents, but a few individuals bloom earlier or later. Elberta and Belle self-pollinated give seedlings that have first bloom as late as a week after the parents. Unfortunately, however, a number of these late blooming sorts proved to be sterile, especially those with desirable fruit characters. It will, however, be possible to produce late blooming sorts. Slappey is a late bloomer and all of its selfed progeny were late. In a cross between Slappey and Early Crawford, the latter very irritable and an early bloomer, the seedlings all bloomed later than Early Crawford and most of them almost with Slappey.

Correlations.

Attention should again be called to two definite correlations. Hedrick (5) established the correlation between the inside of the calyx cup and the flesh color. When the calyx cup is green, the flesh will be white and where the calyx cup is orange, the flesh will be yellow. The writer has extended this somewhat. A green, white or pale cream calyx cup indicates a homozygous white fleshed fruit, a yellow cream to yellow buff calyx cup indicates a heterozygous white fleshed fruit; a deep orange color indicates a yellow fleshed fruit.

Another correlation is that between the color of the leaves and the color of the fruit flesh. Dark green leaves usually indicate a white fleshed fruit and a yellowish cast to the green of the leaves indicates a yellow fleshed fruit. However, recourse must be had to an examination of leaf venation for an exact determination, and the midribs will usually show the color, especially if interposed between the eye and the sun.

An interesting and important correlation is suggested, but has not yet been fully worked out, and that is the relation of red pigment in the twigs, leaf petiole and midrib, to red color in the flesh. This would be very important for those who are breeding varieties for canning, in which all red flesh color must be eliminated.

Ripening Dates.

The inheritance of ripening dates can only be solved by trial, although the general tendency may be shown because of the num-

ber of varieties used in this operation. In estimating dates, the date of first picking is taken as the basis. In crosses between two varieties of different seasons, as Belle x Greensboro, Elberta x Greensboro, St. John x Early Wheeler, there is a compromise in date of ripening; that is, the majority ripen about midway between the two parents, and it is rarely that a seedling ripens before the earlier parent, or later than the later parent. In crosses between varieties of nearly the same season, as Belle x Elberta and reciprocal, Belle x Early Crawford and reciprocal, Elberta x Early Crawford and reciprocal, the majority ripen at the season of the two parents, others ripening as early as two weeks before, to two weeks after, either parent. In self-pollinated progeny, the majority ripen about the season of the parent, extending 3 weeks before to 3 weeks after in the case of Elberta; 2 weeks before to 3 weeks after in the case of Belle; 10 days before to 10 days after in the case of Early Crawford; 3 weeks before to 4 weeks after with Lola; 1 week before to 4 weeks after with Carman; 1 week before to 4 weeks after with Slappey.

The deduction from the above is that a new individual coming at a certain date would be more likely to be secured by crossing two varieties the mean of whose ripening dates would come at the desired period.

Color of Flesh.

White flesh is dominant over yellow flesh. Crosses or self-pollinations of homozygous white-fleshed varieties have yielded all white fleshed seedlings. Heterozygous whites have yielded 3 white to 1 yellow. Yellows have given all yellows. Opportunity is taken at this time to correct tentative statements made in the paper published in the proceedings of this society in 1919, (2), that Elberta and Early Crawford, both yellow varieties, possessed a factor for white flesh. The common resemblances among progeny of crosses are so definite that as soon as practically all had fruited, it was discovered that these supposedly white seedlings from self-pollinated yellow varieties were in reality crosses between the yellow variety and white varieties and the error was due probably to a mixture of seeds or seedlings that might have occured in two of the operations intervening between the pollinations and the planting in the orchard of the seedling trees.

It is interesting to note that predictions made on the basis of correlations of calyx cup and leaf color checked up almost completely with the flesh color of the seedlings.

Texture of Flesh.

Texture of flesh is always an important quality in commercial peach production, but the somewhat recent desire to secure varieties for commercial canning makes the subject even more pertinent.

Firmness of flesh seems to be of two types. First may be considered the firmness that is desirable from the standpoint of a commercially shipped peach, and J. H. Hale is perhaps the best representative of this type among the more widely grown com-

mercial varieties. This, however, is the type of firmness that readily softens on ripening. The other extreme of firmness is the rubbery texture of Early Wheeler which apparently never softens. Closely allied with the latter may be classed the canning peaches, and such varieties as are grown, for example in Chili and South Africa, for transoceanic shipment. Some of these varieties possess the almost rubbery texture of Early Wheeler, but in time, or under the influence of cooking, soften to such an extent that they can be masticated. While no histological studies have been made, it is believed that the cell walls of the latter type are of such thickness, or of such a structure, as to prevent the collapse of the cells after plasmolysis, thus inhibiting the shrinkage of the fruit when canned, which of course is altogether undesirable in the commercially canned product. Both "soft" and "firm" in this discussion really belong to what has been designated as having melting flesh.

TABLE No. I.

Texture of Flesh, Given as Per cent of Total Seedlings of each Parentage.

	Per cent			Number of tough with colored flesh		
	Soft	Firm	Tough	Red	Pink	Clear
Belle self-pollinated	31.5	47.8	20.7	29	10	3
Belle x Greensboro	44.1	38.2	17.7	15	10	11
Belle x Elberta	15.2	80.3	4.5	1	2	..
Belle x Early Crawford	18.4	63.2	18.4	19	2	..
Elberta self-pollinated	14.3	83.2	2.5	3	..	..
Elberta x Belle	22.2	76.7	1.1	1	..	..
Elberta x Greensboro	30.5	68.5	1.0	1	..	..
Elberta x Early Crawford	14.5	82.6	2.9	2	..	..
Early Crawford self-pollinated	22.5	53.7	23.8	6	..	2
Early Crawford x Belle	12.0	56.0	32.0	6	2	..
Early Crawford x Greensboro	22.8	51.5	25.7	9	..	..
Early Crawford x Elberta	13.3	76.7	10.0	3	..	..
St. John x Early Wheeler	52.2	41.0	6.8	2	..	1
St. John x Greensboro	55.0	45.0	....	..	..	..
Early Crawford x Arp	44.5	33.5	22.2	2	..	..
Carmans self-pollinated	42.8	35.8	21.4	3	..	..

Table 1 shows the proportions of the seedlings of each parentage that bore fruits too soft in texture for commercial shipping, satisfactorally firm and too tough. It will be noted that Elberta self-pollinated seedlings produced a high percentage of firm fruits, and wherever Elberta was used as a parent, the result was a high percentage of firm fleshed seedlings. Belle and Early Crawford were mediocre in this respect, but when these two varieties were crossed there is a relatively high percentage of firm flesh seedlings. Greensboro is itself a rather soft fleshed variety, and, although no selfed seedlings have been obtained from this variety, it is probable that it transmits this character, as when used as a parent, even with Elberta, the proportion of soft fleshed seedlings is high.

The behavior of the 44 seedlings from St. John x Early Wheeler is interesting. The seed parent is inclined to have soft flesh while the pollen parent is rubbery. More than half of the seedlings bore

flesh too soft for shipping and 2 were tough. This latter character is obviously a recessive.

The character for producing the tough flesh so desirable for commercial canning is present in Belle, Carman, and Early Crawford to a high degree and to a less degree in Elberta. In most of the seedlings from these varieties there is nearly always present more or less red coloring matter in the flesh, undesirable for canning. However, this coloring matter is frequently light in hue and located around the stone so that it is removed in the destoning operation, or else lies directly under the skin. The adaptability of these varieties to environment is well known, and they may be the basis of a new industry for the East. Already one of our seedlings of Belle self-pollinated has been given a trial at one of the canneries and has produced a satisfactory pack.

ADHESION OF FLESH TO STONE.

In the preliminary report on this work, the data showed that freestone x freestone gave an average of about 2 freestone to 1 cling, or semicling, while freestone x clingstone gave results varying with the degree of clinginess of the parents and with the power of the freestone parent to produce freestone seedlings. Attention was called at that time to the semifree or semicling group, which seems to be composed of border-line cases. The only material changes in the table given in that report have to do with these borderline cases.

This character varies with enviornment. Semiclingstones one year may be either freestone or clingstone the next season; or in the same season, in different localities even within the bounds of a single state, all the variations may occur. So, the previously reported proportions of freestone, semiclingstone and clingstone seedlings, would be varied each season they were reported. The wisest proceedure, in the selection of sorts for trial, would be to eliminate as far as possible all of this unstable group from consideration. Of course, in the early part of the peach season all of the varieties are clingstones or semicling. Whether it will be possible to replace these with freestones is still problematical, although there are grown at the present time two small fruited varieties, one, Japan Dwarf Blood or Japan Dream, a little later than Greensboro, and our Liberty just before Carman, that have been freestone in each season. This then, bids us hope.

We have now some evidence on the behavoir of these borderline cases in crossing. Carman is a semi-cling type, and self-pollinated seedlings from Carman were 4 freestones, 3 semi and 7 clingstones. The number is too small to draw any definite conclusion, and no great number of seedlings from crosses with this parent were obtained, yet it seems well to point out the fact that this type does carry a factor for absolute freestone.

Another border line variety is Lola, but this variety is of the semi free type, that is, it is usually either free, or semifree and rarely clingstone. Table II shows the results with this variety and the varieties used in crossing it. Arp is a very early clingstone variety that produces no viable seeds.

TABLE NO. II.

Adhesion of Flesh to Stone in Peach Seedlings

		Free		Semifree		Cling	
	Total	No.	Per cent	No.	Per cent	No.	Per cent
Lola self-pollinated	57	24	42.0	8	14.0	25	44.0
Lola x Arp	40	6	15.0	5	12.5	29	72.5
Early Crawford self-pollinated	43	29	67.4	.	....	14	32.6
Lola x Early Crawford ..	49	31	63.3	2	4.1	16	32.7
Slappey self-pollinated ..	10	10	100.0	.	....	..	....
Lola x Slappey	24	19	79.1	4	16.7	1	4.2

Lola is almost 50-50 freestone and clingstone. When crossed with Arp, a clingstone, a very high ratio of clingstone seedlings was produced. When crossed with Early Crawford, a 2-1 freestone, a high percentage of freestones is produced; with Slappey, a freestone, a still higher proportion of freestone seedlings are produced. The populations here are small, but these are believed to be indicative of the behavior of these varieties in crosses.

Although it is idle to speculate, yet the evidence points to the freestone character as the dominant one.

SIZE OF FRUIT.

Small-sized parents are to be avoided. It was found that practically all of the selfed seedlings of Early Crawford, Lola, and Slappey were small, and that in crosses with these used as parents the tendency was toward small fruited seedlings. Even in the cross between Elberta and Early Crawford, all of the seedlings bear small fruits.

Belle, while itself under New Jersey conditions, at least, below medium to medium size produces a good proportion of large-sized seedlings, and is able to transmit this character in crosses. Elberta seedlings are practically all large and in crosses, except with Early Crawford, Elberta is able to impress this character.

SUMMARY.

By way of summary, it might be well to review, in a brief way, the contribution made by each parent to its progeny.

Elberta transmits size, yellow color and firmness of flesh, freestone, a variable period of ripening, and a slight tendency to sterility. In self-pollinated seedlings it transmits better quality than that of the variety itself.

Belle is a heterozygous white and so is able to transmit white and yellow flesh, a fair proportion of firmness of flesh, a fair proportion of freestone, a variable period of ripening and of blooming, and a tendency to sterility.

Early Crawford transmits small size, yellow flesh color, a good proportion of firm or tough flesh, a fairly high proportion of freestone, tender pubescent skin, and the acid quality which reacts against this variety in some localities.

Greensboro transmits white flesh, good size and color and hardiness in bud, but softness of flesh, and the clingstone character.

Slappey transmits small size, dry, mealy yellow flesh, lateness of blooming, and freestone.

Lola transmits small size, white and yellow flesh, softness of flesh and mediocre quality, a good proportion of clingstone, and a character for early season ripening.

Dewey transmits late blooming habit, yellow flesh and good quality, soft flesh, tender skin and susceptibility to rot, and pubescence.

Arp transmit clingstone greenish yellow flesh and skin color, and earliness.

Carmen transmits white flesh, tendency to clingstone and proportion of tough flesh.

The seedlings resulting from crossing Elberta and Greensboro are white-fleshed, with plenty of red coloring matter in the flesh which enhances the attractiveness, of large size and productive, but of mediocre quality.

The seedlings from Belle x Greensboro are of large size, white fleshed, attractively and highly colored, resistant to brown rot and of fairly good quality.

In all about 125 seedlings are under extended test on the Station grounds and about 40 at various parts of the state. The most promising are substitutes for Carman, but others are like Elberta and extend the season of Elberta a week before and 2-3 weeks later.

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Solving the Fruit Growers Problems by Plant Breeding

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SOME apology should first be made for the above title. This paper is intended primarily as a presentation of methods used in practical fruit breeding rather than as a record of results achieved. President Blair is responsible for the title and, therefore, responsibility for the contents, also, is gratefully tendered him.

The Ontario Horticultural Experiment Station was established, fortunately, in the heart of a famous fruit district, famous in Canada at least. Surrounded by fruit growers, the Station workers have gradually come to the conclusion that the chief fruit problems are problems of variety adaptability. By variety adaptability I mean not only adaptability to environment, but more particularly market adaptability. The sense in which I use that phrase will become clearer in succeeding paragraphs.

This is not to infer that cultural problems are not of importance also. It is felt, however, that what is most needed now in cultural problems is some method or methods of getting the average grower to put into general practice what we already know of plant nutrition, pruning, etc. Perhaps this thought applies more to the Niagara District of Ontario than elsewhere due to the almost total freedom from crop failure of that section. In any case since 1914 plant breeding has engaged more and more of our attention in the production of varieties to meet the needs of our peculiar market conditions. This, we regard as our most important cultural, or economic problem.

Some of the main problems on which we are working may be here stated.

1. Increased earliness and improved quality and yield in early strawberries.
2. A heavy yielding late strawberry to fill in the season between the main strawberry crop and the Cuthbert raspberry. This is essentially an economic problem to hold pickers profitably throughout the small fruit season, and made necessary by the defection, from disease, of the Marlboro raspberry.
3. An early raspberry to take the place of the Marlboro, and for the reason given in (2).
4. A mid-season raspberry to supplement and possibly finally take the place of Cuthbert which seems to be rapidly succumbing to disease (mosaic).
5. A seasonal succession of peaches of Elberta type as to vigor, productiveness, shipping quality, etc., but of improved dessert and home canning quality if possible.
6. More desirable early yellow flesh peaches of the season of Greensboro, and of good shipping quality.

   The above peach breeding projects if successful would permit of local markets absorbing more peaches because of extended season, and would further permit of greatly extended plantings through the opening up of the Canadian West Market. We can ship Elbertas there quite successfully, but not other varieties, so that the shipping season is extremely short. The Elberta, with us, is over-planted with consequent overproduction at *one season*, but not for the season as a whole. More even production throughout the season is necessary. That is essentially market adaptability.
7. Varieties of grapes with the shipping, storage, and dessert

qualities of the Rogers' Hybrids and the productiveness and cosmopolitan tastes of the Concord. The Niagara District produces annually from 1500 to 1800 cars of grapes, but acreage and total yield could probably be doubled if the above type of grape could be produced. It woud permit of the long haul to the prairie provinces, and of storage for local markets for a considerable period, till the New Yeer or later.

In addition to the above fruit breeding projects, several other problems are receiving more or less attention. These include hardiness in wood and bud of the peach; a hardy red winter apple; blight resistance in pears; hardiness and thornlessness in blackberries; drought resistance and thornlessness in gooseberries.

In connection with the last named project, it may be of interest to note that we have successfully crossed the gooseberry and black currant with the following result. All of the resulting plants, about a score, are of either one of two types. One type is indistinguishable from the black currant (female parent in cross) in all gross characters as growth, foliage, fruit, odor, etc. The other type closely, though not entirely, resembles the gooseberry in form of plant, foliage, etc., but is practically thornless; in other words a thornless gooseberry which would seem to be the end of our quest. Nature, however, overlooked a comparatively minor detail. The plants blossom but bear no fruit. They are sterile. Both currants and gooseberries are growing alongside so that there is ample opportunity for cross-pollination if such were needed. Probably a Dorsey or an Auchter could tell us what is wrong. In the meantime we are selfing the black currant type, but doubt the result. The Topsy black currant, originated at Ottawa is a gooseberry-currant cross, but selfed seedlings show no breaking up.

Strawberry Breeding

Some 10,000 hybrid plants have been fruited in the past eight years. No further crosses have been made since 1920, the effort since that time being to discard as rapidly as possible from the material already growing in an effort to prevent being completely snowed under. We believe in working with large plant populations, but we are also coming to believe in early and severe culling out, even though what might have been a seedling or hybrid of merit is occasionally destroyed. If we were making genetic studies we might work differently. But we are not. We are working primarily for variety improvement, sufficient notes of course being made on the behavior, desirability, etc., of each cross as a guide to future work. This holds true of the other fruits as well as strawberries.

The method followed with strawberries has been to severely cull out in the first and second years of fruiting, propagate and grow the selections in double 25 foot rows, select rigidly again, grow in double 50 foot rows, select once more and distribute to growers for the final trial. Following this plan the 10,000 have been rapidly reduced to one good variety, 17 that may be good,

and 28 that have only reached the 25 foot row fruiting test. Few will survive.

Our one good seedling (H. E. S. No. 2) is a cross of Pocomoke x Ozark. Parenthetically it may be noted that of innumerable crosses made, 8 of our first 10 selections have Ozark as either one or the other parent. H. E. S. No. 2 is an early season berry, two or three days earlier than Bederwood or Michels, and in our judgment superior to those varieties in every way. Particularly the fruit holds its size well throughout the season.

Raspberry Breeding

As parents the three varieties, Marlboro, Herbert, and Cuthbert have been used almost exclusively up to the present. In new work other varieties are now being used. No description of these well known varieties need be given here. Marlboro has been used primarily for earliness and Cuthbert for quality. The hardiness of the Herbert is not an important factor in the Niagara District.

During 1913 and 1914 these three varieties were both selfed and used in reciprocal crosses. As shown in the accompanying table a total of 5,329 resulting plants were finally set in the field to fruit. By 1918, this was reduced to 50 which were then propagated and grown in double 50 foot rows for further test. By 1921, 10 only were left and these have been set in a new plantation, not yet fruiting, with a double 50 foot row of each. Of these 10, one is considered outstanding and is being propagated as rapidly as possible.

This hybrid (No. 14038) is a cross of Cuthbert by Marlboro. Compared with Cuthbert with which it competes in season, No. 14,038 is an equally or possibly more vigorous grower, canes stouter, more upright, and entirely free of the small spines common to Cuthbert. The fruit is larger and of firmer texture so that it should prove a better shipper. The fruit is more exposed on the cane than the Cuthbert and therefore easier to gather. On the other hand, No. 14,038 is of somewhat poorer dessert quality than Cuthbert and the berry is of lighter color, making it less desirable as a canning berry. However, it is probably sufficiently good in both these respects that they need not necessarily be considered faults.

Referring again to Table I it is interesting to note that the only hybrids to survive the second weeding out were those with Cuthbert as one of the parents. Marlboro x Herbert crosses of which there were 1,100 plants (counting reciprocals) gave only four saved in the first selection and none in the second. Herbert x Cuthbert was little better, seven surviving the first selection and two the second, out of 1,688 plants originally. The bulk of those selected both numerically and in percentage have been in the Marlboro x Cuthbert crosses, 37 surviving the first selection and eight the second out of 1,972 originally. Nothing of account resulted from selfing, though in fairness, the number of plants grown was considerably less.

TABLE No. I.
Raspberry Breeding 1913 and 1914.

Cross	Hybrids fruited	1st Selection 1918 (25 foot rows)	2nd Selection 1921 (50 foot rows)	Promising
Marlboro x Cuthbert ...	1,435	24	5	....
Marlboro x Herbert	700	4	..	....
Herbert x Marlboro	400	..	..	....
Herbert x Cuthbert	1,038	6	1	....
Cuthbert x Marlboro ...	537	13	3	1 (No.14038)
Cuthbert x Herbert	650	1	1	....
Marlboro (selfed)	140	2	..	....
Herbert (selfed)	316	..	..	....
Cuthbert (selfed)	113	..	..	....
Totals	5,329	50	10	

PEACH BREEDING

In breeding for a seasonal succession of peaches of the Elberta type two methods have been followed. First, open pollinated seedlings have been grown and fruited in considerable numbers. Second, definite crosses have been made, the resulting number of trees being, of course, much smaller with this method, owing to the various limiting factors incident to hand pollinations.

Approximately 2,200 open pollinated seedlings of Elberta have been fruited since 1918. In one block of 900 fruiting in 1921 for the first time, the selection record has been as follows:— In 1921, 49 trees left for further observation; 100 left which did not fruit; remainder destroyed. In 1922, the remaining 149 destroyed with the exception of 28 trees, six of which did not fruit; 19 considered of possible value, two promising and one very promising, No. 150,369.

In a second block of 1,000 Elberta seedlings, fruiting in 1921 for the first time, 109 non-fruiting trees have been left, 38 have been retained for further trial, and one selected as promising, No. 174,770. A further block of 50 Elberta seedlings have given two promising late season peaches No. 173,527 and 173,528.

With rare exceptions the hundreds of Elberta seedlings bear a marked resemblance to the parent tree in growth characters and in fruit. The parentage of but few could be mistaken. Probably 15 or 20 per cent could have been propagated and distributed as Elberta with no one the wiser. Approximately 3 per cent were white fleshed and 15 per cent semi-cling or clingstone. A fair number were moderately good in quality, none exceptional, the majority, however, being of Elberta quality, or worse. The variation in season from Elberta, with a few notable exceptions, was slight, ranging from a week before to a week after the regular Elberta season.

This constancy to parental type has been just as pronounced where other varieties have been used. Five hundred open pollinated seedlings of Longhurst could not be mistaken for anything but Longhurst seedlings. Only one was retained, more to pre-

serve the type than for any other reason. Five hundred and fifty open pollinated seedlings of Lemon Free were almost identical with the parent. Only a very occasional tree bore fruit with even a suggestion of color, other than dead yellow. There were of course slight variations in season, clinginess, flesh texture, etc., but nothing marked. Practically all were destroyed. none were promising. Six hundred New Prolific seedling gave similar results, as also did 200 Reeves Favorite seedlings, in resemblance to parental type. In the case of the Reeves Favorite, however, several were of sufficient promise to warrant saving them. A block of 700 Early Crawford seedlings were uniformly high in quality of fruit, but were practically without exception as unproductive as the parent, and like it in other ways.

This suggests the possibility of propagating peach varieties from seed. So far as our observations go, the only objection is the increased susceptibility to disease which F_2 trees show.

The fact that open pollinated seedlings of peaches come so true to type, suggests that they are usually self-pollinated under orchard conditions. The pits used in our work were taken from our variety test orchard in which were upwards of 150 varieties with only a few trees of each variety. There was every opportunity for natural crossing. That natural selfing is the usual condition is also indicated by the small percentage of promising seedlings in the open pollinated lots as compared with the hybrid progeny. We have found that the known hybrids give a much higher percentage of worth while seedlings.

In the definite peach hybridizing work we have crossed in particular Elberta with several other varieties, notably Greensboro, Yellow Swan, Arp, St. John, and Early Crawford. These latter are all earlier in season than Elberta. The hybrids have been uniformly intermediate in season. In the case of the Elberta x Greensboro cross for example this necessitates going to the F_2 to secure the full benefit of the factor for earliness carried by the Greensboro. In this particular cross there is also another reason for going to the F_2 which will be evident a little later.

Elberta x Arp in particular appears to be a promising cross. Of 29 trees fruited. 16 bore quite desirable types of fruit, very handsome in coloring and general appearance. One ripening about 10 days earlier than Elberta is quite promising, No. 160,110.

Returning to the Elberta x Greensboro cross, it is interesting to note that the F_1 trees, 15 in number, all bore white flesh fruit. Of various crosses in which we have used a white flesh peach as one of the parents, we have fruited 36 trees, and all were white flesh. This, and other observations to be noted later, lead one to question the supposed origin of the Elberta. The pit from which the original Elberta grew came from a Chinese Cling (white flesh) tree close to which were growing Early Crawford, Late Crawford, Oldmixon Cling and Oldmixon Free. Early Crawford is the supposed pollen parent. If as seems likely, yellow flesh is recessive to white then a white x yellow cross, Chinese Cling x Early Crawford, could not possibly give a yellow flesh seedling.

Unless of course Chinese Cling is heterozygous for color which it may very well be. Consider also that 97 per cent of the Elberta seedlings that we have fruited are yellow flesh and 100 per cent of selfed seedlings of Elberta are yellow flesh, though in this latter case only 21 trees, an insufficient number, have been fruited. However, selfed seedlings of eight other yellow flesh varieties for a total of 58 trees have been fruited and all were yellow flesh, indicating strongly that yellow flesh acts as a pure recessive. Four trees of Early Crawford selfed were all yellow flesh. The recessiveness of yellow flesh is further indicated by the fact that 73 trees representing nine different yellow x yellow crosses, all bore yellow flesh fruit. Selfed seedlings of Leamington a white variety gave a mixed population for color.

It is perhaps more significant in considering the parentage of Elberta that in over 2,200 open pollinated and selfed seedlings of Elberta, there have been none with fruit resembling Early Crawford in any visible way, at least to the casual observation, and only three which were as early, or earlier in season, than the Early Crawford. The remainder revolve in season around the Elberta itself.

The writer ventures the opinion that Elberta is a natural selfed seedling of Chinese Cling, and a recessive yellow breeding true for that color. This opinion is based largely on the adherence to Elberta type of Elberta seedlings rather than on color inheritance which, however, is significant.

Summing up our peach breeding for a succession of Elbertas we have thus far, one seedling, No. 150,369, ripening in St. John season; two, Nos. 174,770 and 160,110, ripening about midway between St. John and Elberta, and two ripening about a week to 10 days after Elberta, Nos. 173,527 and 173,528. These are all Elberta type peaches, equal to Elberta in all respects so far as present limited observations go, varying only in season, and being of higher quality. Some have fruited only one season, some two, yet we are already propagating. Our purpose is to give the trees one more year's test, discard or hold for further test, together with the nursery stock, those which do not measure up in this further test, but distribute for immediate trial those which continue to look promising. In the final analysis it is the commercial test which counts, and we want that test at the earliest possible date. In apples, Macoun has estimated that a period of 40 years is required to originate, test, propagate, and popularize a new variety. Figuring on the same basis a variety of peach would require perhaps 30 years. We hope, by lopping off a year here and there, and by the fact of being in the heart of a fruit district, to cut the time to 20 years or less, and other fruits in proportion. In early peaches, for example, we can select and propagate the same season, since fruiting season is on or over before the budding season.

Grape Breeding

As previously noted, the chief objective here has been the production of a variety or varieties having the carrying, storage and dessert qualities of the best of the Rogers hybrids, together

with productiveness, or in other words, self-fertility. Lest anyone should become needlessly excited let me say that this objective has not yet been realized, though we hope that somewhere in the hybrids now growing, the happy combination will be found. However, the work to date has not been without its value and there are, therefore, included in this paper a few observations which may prove of interest to other grape breeders.

The bulk of the grape work has been concentrated in a block of approximately 21,037 vines of which 1,646 are open pollinated seedlings, 3,711 selfed seedlings, and 15,680 hybrids with both parents known. The open pollinated seedlings represent 11 parent varieties, the selfed seedlings 28 varieties, and the hybrids 64 different combinations with one of the Rogers hybrids the usual female parent, though Brighton, Campbell, Concord, Niagara and Worden have also been extensively so used.

Approximately half of these vines were destroyed in 1921, before reaching bearing age, because of constitutional weakness of one kind or another. In 1922 the majority of the remaining vines fruited and were severely culled on fruiting characters so that of the original 21,037 only 1,804 now remain. This includes approximately 900 vines which have not fruited. It is significant that in culling down to this number 90.5 per cent of the open pollinated seedlings have been destroyed, the same percentage of the hybrids and 95.5 per cent of the selfed material. Also in the selfed vines many were left, not because of merit, but more for study and further breeding.

As in the case of peaches, this may appear to you as being rather severe selection while the vines are still young and fruiting characters perhaps not permanent in quality of berry, size of bunch, etc. Undoubtedly these and other characters are often modified to some extent in succeeding years. However, we feel that by working in original large numbers, we can cull severely and still have left a very considerable number of plants containing the best of the particular parentage. Then too, if we did not cull severely we would have to practice wider planting with consequent increased land area, or decreased numbers of plants. Peaches and most tree fruits are planted 7 x 10 feet. Grapes are planted 2 feet apart in rows 4 feet apart so that the block of 20,000 vines occupies less than six acres.

Niagara and Vergennes selfed gave particularly weak progeny, only an occasional vine out of hundreds growing strongly enough to be trained to a low wire. Other varieties selfed, while showing more vigor in the progeny than the above, yet were distinctly weaker as a whole than hybrid populations. Of 49 Concord selfed for example, none were worth retaining, being generally inferior to the parent. The same was true of Worden, Agawam, Campbell, Lucile, McPike, Moore, and a few other lesser known varieties were somewhat better, from 2 to 5 per cent being retained.

In the crossing work three varieties have shown up particularly well as parents. These are Agawam, Campbell and Brighton.

Two others of somewhat lesser value are Diamond and Winchell. Agawam x Niagara is a promising cross, though as previously noted Niagara selfed is useless. Concord and Worden selfed were superior to Niagara, yet when crossed with Agawam they proved distinctly inferior to Niagara as pollen parents. Brighton x Campbell, Concord and Worden proved promising in all three cases. Campbell generally whether used as male or female parent is promising, imparting size of berry, size of bunch, quality and general desirability to a surprisingly high percentage of its progeny.

Some interesting observations on fruit color inheritance were noted and are shown in the accompanying table.

TABLE No. II.

Observations on Inheritance of Fruit Color in Grapes

Cross	Parent Colors	No. of Vines	Per cent Blue	Per cent Red	Per cent White
Agawam x Campbell	R x B	50	96	...	4
Agawam x Concord	R x B	172	44	46	10
Agawam x Niagara	R x W	148	...	100	...
Agawam x Worden	R x B	254	62	34	4
Brighton x Campbell	R x B	1,801	100	...	...
Brighton x Concord	R x B	969	Mostly blue, a few reds and whites		
Campbell x Winchell ...	B x W	239	100	...	...
Campbell x Read	B x B	231	100	...	...
Niagara x Delaware	W x R	86	...	100	...
Niagara x Diamond	W x W	154	...	...	100
Niagara x Winchell ...	W x W	420	...	...	100
Niagara x Read	W x B	484	100	...	...
Herbert x Campbell	B x B	567	100	...	...
Herbert x Concord	B x B	590	Mostly blue (or black) a few reds and whites		
Herbert x Niagara	B x W	794	55 (appr.)	45 (appr.)	None
Herbert x Worden	B x B	776	75 (appr.)	25 (appr.)	None
Salem x Niagara	B x W	320	...	All red or white	
Worden x Delaware	B x R	15	100	...	...
Worden x Diamond	B x W	20	Mostly blue, a few red and white		
Worden x Read	B x B	34	100	...	...

The number of vines given in the third column is the total number grown for the particular cross. However in most cases only about half of these were allowed to reach fruiting age and the color percentages are, therefore, on half the totals shown. Blue, black, etc., are classed as one color and also gradations of red as one color.

Briefly analyzing this table, it will be seen that:—

White x white gave 100 per cent white progeny—Niagara x Diamond & Winchell.

Red x White including reciprocal color cross gave 100 per-cent red progeny in two cases, Agawam x Niagara and

cient fertile pollen for the setting of seed. Similar to the other varieties of the Rural group, the Sir Walter Raleigh is a weak pollen producer and for this reason the South American variety was used as the pollen parent.

The F_1 generation consisted of 105 seedlings. One of these produced seed balls the first year, 1910. There is no record of any seed production for 1911. Six of the 42 seedlings selected for growing in 1912, produced seed balls. Three of the six seedlings which produced seed, were selected as being superior in desirable commercial characters. From these three seedlings F_2 populations were grown in 1913. These F_2 populations consisted of 160, 500, and 2161 seedlings respectively. Degeneration diseases destroyed this lot of seedlings in 1914. In 1922 an F_2 population of 2400 seedlings was grown, from the same F_1 seedlings from which 2161 seedlings were grown in 1913. In this particular cross it was possible to select desirable F_1 plants which produced an abundance of self-fertilized seed.

Color of Tubers

With a few exceptions, the most notable of which is the Early Ohio, the consuming public prefers a white tubered variety. For this reason it was hoped to obtain a white skinned variety which also had other desirable characters.

The tubers of the South American variety were pink, or light red. Four of its seedlings which were grown produced plants which showed the following tuber colors; 1 white, 1 slight pink, 1 medium red, and 1 dark red. These meager data indicate that it was heterozygous for red tuber color. In 1910, 37 seedlings of Sir Walter Raleigh, a white-tubered variety were grown. They were classified as follows: 25 white, 1 light pink, 4 dark pink, 2 medium red, 1 dark red, and 4 medium purple. This surprizing segregation of a blue-sprout, white-tubered variety showed that it was heterozygous for purple and red color. Apparently in white-tubered varieties having colored sprouts a heterozygous condition exists, and a homozygous condition of the factors is necessary to produce tuber color. Other white-tubered, blue-sprout varieties gave similar progeny. This does not agree with Salaman's (2) results. He found purple and red tuber color to be dominant to white. Stuart (3) and Young (5) concluded from their work that white was not always recessive. The discrepancy with Salaman's results in regard to purple color may possibly be explained by the fact that the purple color of the tubers with which Salaman worked may have been due to purple flesh color, as the variety used was the purple fleshed Congo Black. A variety of Congo Black in which the color of the tubers was due to color of flesh, was grown at the Minnesota Experiment Station, was self-fertilized, and the following groups for the tuber color were obtained; 18 purple, 35 medium purple, 18 white. Purple flesh is dominant to white with apparently but a single factor difference involved. The factor for skin color was either absent or closely linked with flesh color. The former was probably the case as the degree of external coloring corresponded to the degree

of flesh color. In the blue sprout varieties, to which the Sir Walter Raleigh parent belongs, the factor for flesh color is not involved, as all seedlings possessed white flesh, color of the tuber being due to the pigment in cells just beneath the skin. In 1910, 104 plants of the cross between Sir Walter Raleigh and the South American variety were grown. They were classified in regard to tuber color as follows: 66 white, 7 light pink, 2 medium pink, 3 dark pink, 7 medium red, 1 dark red, 6 light purple, 11 medium purple, and 1 dark purple. The proportion of white tubered to colored tubered seedlings was 66 to 38. In this case it was possible to select white-tubered fertile seedlings for the F_2 generations. The results obtained on tuber color from the parents and in the seedlings of the cross are summarized in Table I.

TABLE No. I.

Frequency Distribution of Color of Tubers of the Parent Varieties and the Seedlings of the Cross

Parent Stock	Color of Tubers									
	White	Light Pink	Medium Pink	Dark Pink	Medium Pink	Dark Red	Light Purple	Medium Purple	Dark Purple	Total
South American Variety	1	1	..	..	1	1	..	..	..	4
Sir Walter Raleigh	25	1	..	4	2	1	..	4	..	37
Seedlings of Cross	66	7	2	3	7	1	6	11	1	104

An F_2 generation was grown from three white-tubered F_1 seedlings. Two of these seedlings from which families of 160 and 500 seedlings respectively were grown in 1913, bred true for white tubers. The third seedling did not breed true for white tubers. Of 2161 seedlings grown of the latter seedling in 1913, 6 plants had pink tubers, 3 plants had tubers which were slightly tinged with pink at the seed end, and 2152 plants had white tubers. A second F_2 population from the same original seed secured in 1912, consisting of 2400 individuals, was grown in 1922. Like the population obtained in 1913, the large majority of the seedlings had white tubers, a few varied from pink to red, and one seedling had white tubers with distinctly pink eyes. Many of these first-year seedlings set tubers near the surface of the soil where a portion, or all the tubers of a seedling, were exposed to sunlight. As sunlight brings out color otherwise hidden in white-tuber seedlings, a definite classification of these could not be made. The results obtained from the seedlings of the self-fertilized parents and from the F_1 and F_2 generation of the cross, suggest that the factors which are concerned in tuber color are expressed only when in a homozygous condition. This fact made it relatively easy to obtain a large F_2 population of white-tubered seedlings from which seedlings having other commercially desirable characters could be selected.

Shape

The shape of tubers in the parent varieties was of the well known Rural type. The seedlings of the Sir Walter Raleigh varied in shape from long to round flattened, with many intermediates, indicating that this variety is heterozygous for the factors determining tuber shape. Of the four seedlings of the South American variety, 1 was round flattened. No record was made of the shape of the other seedlings. The F_1 population of the cross grown in 1910 consisted of 105 seedlings. Forty-one of these were grown in 1912 and were classified as to shape as follows: 9 long, 21 oblong, and 11 round. Two of the F_1 seedlings classified as long, bred true for tuber length. The number of plants studied was 160 from one seedling and 500 from the other. Another F_1 seedling classified as round, produced F_2 progeny varying from roundish oval to oval in shape. Two F_2 populations were grown of this seedling, one in 1913 and another in 1922. The populations consisted of 2161 and 2400 seedlings respectively. The results obtained correspond to what was expected from the results obtained by Salaman (2), who found that shape was essentially dependent on the presence or absence of a single factor for length. As shape of tuber is an important commercial character, it is gratifying to know that seedling populations having tubers of desirable shape, are easily obtained, a condition which facilitates the work of making selections for other desirable characters.

Maturity

The parent varieties were both late maturing requiring 120 days or more to mature at University Farm. The parent varieties produced in each case medium early to late maturing seedlings, showing that both parents were more or less heterozygous for the factors determining time of maturity. The F_1 seedlings of the cross varied in time of maturing between 100 and 140 days. An F_2 popuation of an F_1 seedling which matured in 110 days was grown from seed in 1922. These seedlings differed from each other in time at which they matured the first year by more than 60 days, indicating that definite segregation as to time of maturity was occurring. These results show that in this particular cross between two late maturing varieties, both early and late maturing varieties could be obtained.

Summary

1. In 1909, a cross was made between Sir Walter Raleigh and an unnamed variety from South America for the purpose of obtaining a commercial variety more resistant to the conditions causing tip burn than the varieties of the Rural group.

2. Seed collected of F_1 seedlings in 1912 was used to grow F_2 populations in 1913, and in 1921 and 1922.

3. In this particular cross between a variety of medium or small viable pollen production and a variety producing abundant fertile pollen, it was possible to select desirable F_1 plants which produced an abundance of self-fertilized seed.

4. In this cross between parents heterozygous for tuber color,

by selecting white-tubered seedlings in the F_1, a large F_2 population of white-tubered seedlings was obtained from which selection could be made of seedlings having other commercially desirable characters.

5. The results obtained on tuber shape agree with those obtained by Salaman (2) and indicate that shape essentially depends on the presence or absence of a single factor for length. A condition which makes it easy to obtain seedling populations having tubers of desirable shape.

6. In this cross between two late maturing varieties whose progeny showed them to be heterozygous for time of maturity, both early and late-maturing seedlings were obtained in the F_2 generation.

While it is evident from the results obtained that the heterozygous condition of the parent varieties complicates the combining of the desirable characters of the parent varieties into a commercial variety, it does not prevent such combinations from being obtained if sufficiently large populations can be grown. It necessitates growing from 50 to 100 seedlings in the F_1 generation to allow of selection among the fertile seedlings, and it may be necessary to grow F_2 populations from a number of F_1 selections.

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The Relation of Stocks to Scions with Special Reference to Citrus

By H. J. WEBBER, *University of California, Berkeley, Calif.*

MUCH attention has been given by horticulturists to observations on the reciprocal influence of stocks and scions, but as yet little fundamental investigation has been devoted to the subject and the principles underlying the reactions observed are as yet little understood. It is hardly to be supposed that the phenomena observed are altogether fortuitous. Doubtless they are based on general physiological laws and could be predicated if our knowl-

edge was sufficiently extended. It is in the hope of stimulating studies on the subject that the present paper is presented.

Fruit growers universally recognize the practical importance of a knowledge of stocks, but the practice pursued in the case of every industry familiar to the writer is largely imperical and based on limited knowledge obtained mainly by the "cut, fit and trial" method.

Apparently the question of whether one species will bud on another and form a fully congenial union can only be determined by trial, but when such congeniality has been established between two species, it would seem that if we understood the laws of growth and nutritional relationships, we should be able to predict with some degree of certainty what reciprocal relationships should exist between different varieties of them when used as stock or scion respectively.

The numerous horticultural varieties or clons of any species such as orange, apple or peach, are only a few superior variations selected among the millions of different variations that might be chosen if a sufficient number of seedlings were grown. Many records of different results have been obtained by using seedlings from these different clons as stocks. The principal characters of the named clons are known to us and we know them to differ markedly in many cases in growth rate, season of maturity, habit of branching and other characters. It is certainly reasonable to assume from what we already know of stock and scion reactions that these different characters present in stocks will cause different reactions on the scions, and indeed many such cases have been recorded.

Yet the great mass of our orchard trees of all kinds continue to be grown on seedling stocks of unknown character and parentage, and little is being done to stimulate a knowledge of the facts among orchardists that would lead to a demand for the use of more exact methods of stock selection. As an illustration, French seedlings are being used in increasing quantity for apple stocks, and these come from the French cider apples, mainly seedlings, I am informed, which show innumerable variations. The writer in an earlier paper called attention to the marked variation in size of growth exhibited by various of these French cider apples as shown by varieties grown in the orchard of the United State Department of Agriculture at Arlington, Virginia.[1] Some varieties of the same age were several times larger than others. Gardner, Bradford and Hooker[2] have described variation in a seedling apple orchard at the Misssouri Experiment Station in which trees of the same age ranged in circumference from 1 inch to 16 inches. How can good uniform orchards be produced from the grafting of such variable stocks?

[1]Webber, H. J. "The Improvement of Root Stocks Used in Fruit Propagation," Jour. Heredity 11, 291-299. Oct. 1920.

[2]Gardner, Bradford and Hooker. "Fundamentals of Fruit Production," p. 597.

Good and Poor Orchards

It is a common observation that some orchards grow and develop satisfactorily from the time of planting and are always pointed out as good orchards, while other orchards on similar land and treated just as well, so far as can be determined, are always slow in growth, variable in character, and unsatisfactory. It is also a matter of common observation that the different trees, whether of the same or of different sizes vary greatly in yield.

Such differences, when a standard variety has been used, have commonly been ascribed to differences in local environment, and different care, but it has become quite evident that all of the variation exhibited cannot be thus explained.

Within the last decade, attention has been directed to the possible bearing of bud variation in the scions on this difference betweeen trees and the importance of taking buds only from good yielding trees known to produce fruits of the standard type of the variety. While the writer fully believes in this policy of "bud-selection" for citrus orchards particularly, he does not believe that this explains all the variations in size and yield found in orchards.

If a careful study is made of all of the factors that might be expected to cause this variation, it would seem to the writer that one could scarcely escape the conclusion that the stocks used must be considered as the most likely cause of a considerable part of this tree variation as the stocks are different seedlings from many different parents of unknown character and thus probably no single one is ever just like any other one. In a single orchard the environment and care while variable is always very nearly alike, and the buds are all from a known standard and bud mutations, or sports, are at most of rather rare occurrence.

Variations in size of trees similar to those found in orchards are also found regularly in nurseries among trees of the same variety, in the same nursery row, and on the same stocks (so far as we have thus far differentiated the stock). As an illustration, nursery trees of the Washington Navel orange budded on sour orange stocks at two years of age, when ready to be transplanted into the orchard, may differ in size from one-fourth inch to one and one-fourth inches in diameter. This same variation in size of nursery trees exists regardless of whether the stock used is sour orange, sweet orange, grapefruit or trifoliate orange, the four kinds of stocks most commonly used in citrus progagation.

For several years the writer has been engaged in an attempt to analyze the reasons for this variation and determine what it means in the production of an orchard. Sour orange stocks are seedlings of the sour orange and are grown from sour orange seeds taken from many different seedling sour orange trees growing here and there in Florida and California, and of widely different types.

Ninety-five per cent of our millions of citrus trees are budded on sour orange stocks—just sour orange, not "Smith's Best" or "Jones' Improved," but just sour orange. If we grew a thousand of these sour orange seedlings such as we use for stocks up to fruiting age and studied them carefully, it would be surprising if we could not find among them several hundred different

types, distinguishable one from another by some clearly marked character. There would certainly be dwarfs and giants and many intermediate types. Is it not unreasonable to assume that all of these types will give good results when used as stocks on which to bud our carefully selected varieties, and yet that is exactly what has always been done and is our present practice.

Experiments with Large and Small Nursery Trees

To determine definitely what effect the use of large and small nursery trees such as described above had on the character of the trees grown in the orchard, an experimental orchard planting was made in the spring of 1917. While the preliminary publications* on these experiments may be familiar to many, it will be interesting to present the results up to date.

In 1914 a nursery was started at the Citrus Experiment Station to grow trees for a fertilizer experiment. To get trees of as uniform size as possible a good batch of sweet orange seed-bed stock was purchased and sorted over, about 15 per cent of the small stocks being discarded. Those retained were grown in a carefully prepared nursery and the next year were budded to Washington Navel, Valencia and Marsh Grapefruit, the buds used being taken from carefully selected performance record trees. In the spring of 1917, when the buds were two years old, they were used in planting an orchard of about 60 acres to be used mainly for the fertilizer experiment mentioned. An inspection of the nursery at this time showed it to be a very good nursery of what would ordinarily be considered remarkably uniform trees. Still there was considerable variation in size and as more trees were grown than were needed, only the best were dug for planting. In order to obtain further information on what this variation meant, it was decided to make small trial plantings of the different sized trees.

Small, intermediate, and large sized nursery trees of Washington Navel, Valencia and Marsh Grapefruit were selected. These were dug bare root in order to determine whether the roots were healthy or had been injured accidentally. They were then planted in the experimental orchard in adjoining rows in June, 1917, so that they are now seven-year-old buds and have been in the orchard five years. Eighteen large, 18 intermediate, and 18 small trees of each variety were used. It might be supposed that the difference in size would rapidly disappear but this has not been the case. The different size grades in the different rows are almost as distinct today as they were when planted five years ago. The large remain large and the small remain small. The following table gives the average volume in cubic feet of the tops of the trees of each grade and each variety after they had been growing two years in the orchard and also at the end of five years in the orchard.

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*Webber, H. J., "Selection of Stocks in Citrus Propagation" Cal. Agr. Exp. Sta. Bull. 317, Jan. 1920.

"The Improvement of Root-Stocks Used in Fruit Propagation" Jour. of Heredity, 9:291-299, Oct. 1920.

"Citrus Root-Stock Problems" California Citrograph, 8:391. Oct. 1922.

Average Size of Tops of Citrus Trees Grown from Nursery Trees of Different Size. In Cubic Feet.

Varieties	Large	Intermediate	Small
Measured April, 1919, After Two Years in Orchard.			
Washington Navel	31.25	11.68	7.25
Valencia	16.78	9.03	7.49
Marsh Grapefruit	15.24	9.16	6.17
Measured May, 1922, After Five Years in Orchard.			
Washington Navel	190.17	118.28	89.65
Valencia	286.56	170.78	179.59
Marsh Grapefruit	286.40	219.33	147.67

It will be noticed that all of sets of trees after five years retained their same relative rank except in the case of the Valencia where the row of small sized trees are now slightly larger in top volume than the row of intermediate sized trees.

The trees began bearing a few fruits in 1919-20 and an examination and record showed that the large trees as a whole began bearing earlier than the trees of smaller size. A tree yield record was to have been started last winter, but was so interrupted by the freeze and by pilfering as to be considered worthless. It can, however, be stated that examinations have been made many times in the field at various stages of development, and by many different observers, and never has anyone questioned but that the crop on the large trees was far heavier than on any of the other grades of trees. The writer believes it would be a safe estimate to place the average total yield of the large trees in each variety as double that of the small trees.

However convincing this experiment may be it includes only small numbers of trees and one would like further evidence on a point of such importance. Very fortunately further evidence has been found to exist in a 60 acre Valencia grove planted by William Hertrich on the San Marino Ranch about two miles southeast of Pasadena. As this is an important case, it will be rather fully described. (The description given has been read and approved by Mr. Hertrich).

Large Trees Superior in Large Orchard Tests

The details are as follows, according to Mr. Hertrich: In 1913 after the freeze, the ranch bought sour orange seed bed stock from John R. King of Monrovia, California. This stock was planted in a nursery, no selection being made and no grading being given at the time of planting. The seedlings were set without reference to size.

Out of 10,000 seed bed stock purchased, about 5,000 nursery trees were obtained. The largest seedlings were budded in the spring of 1914 and others were budded in the fall of 1914. The buds used were selected from the best yielding part of a Valencia grove on the San Marino Ranch. (Not trees selected on record.)

In using these nursery trees in orchard planting the largest were taken out and planted first, then the next best, and finally the small trees were also used. Mr. Hertrich states, "The reason for planting the trees as we did was because our original plans called for only 20 acres, but after picking out the best trees, we had a number of good trees left and we decided to put them in. After planting these, having plenty of space, we decided to put the balance in, although from a commercial standpoint, the trees in the last planting were not up to standard. While this was not projected as an experiment, the result is that in one portion of the grove, 20 acres, the planting of the large trees are grouped together, in another portion, 20 acres, the next largest or intermediate size (second select) are grouped together, while in another portion, 20 acres of the grove, the small nursery stock was planted. The first 20 acres planted with the selected large trees was set in the orchard in July, 1916. The second 20 acres, in which the second select or intermediate sized trees were used, was planted in March and April, 1917, as was also the third 20 acres in which the small sized trees were used. In transplanting the trees were all dug with bare roots (not balled)."

An examination of the grove now (at the end of five years) shows remarkable differences in the different plantings. That portion of the grove planted with the large trees (first selects) has made a fine growth. The trees are uniform in size, very large, vigorous and fruitful. These trees in general are about 10 feet in height, with a fair spread. The most remarkable thing about this portion of the grove containing about 20 acres is the uniformity of the trees. All are uniformly large and fruitful.

The portion of the grove planted with intermediate sized trees (second selects) has made a fair growth, but the trees are much smaller than in that part planted with large trees, and while fairly uniform, contains, more undersized trees and almost none are as large as the smallest sized trees in the large nursery tree section. These trees average about 5 to 7 feet in height with a corresponding reduction in spread.

The portion of the grove planted with the small trees is very variable in tree size and growth and is much inferior to either of the other two plantings. Here the height of trees is from 4 to 5 feet with small spread and unsatisfactory growth.

While the soil of this grove is more or less variable, there is little difference and the soil in some portions of the grove planted with small trees is certainly as good as that where the large trees are planted. It seems certain that the soil can not be considered as a material factor in causing the difference in growth described. It could not apparently be due to the buds used as these were all Valencias, from a good producing grove. The trees were all planted bare-root so that any with diseased, mal-formed or injured roots would have been noticed and discarded.

The results obtained here, substantiating as they do so completely the experiments at the Citrus Experiment Station at Riverside, leaves little question that a marked difference is uniformly to be expected from planting different sized nursery trees when these

are taken from the same nursery, grown under the same conditions, and of the same age.

It is the writer's belief that this can be taken as an established fact for citrus trees, and that it has a very important practical application.

While the writer knows of no published results of tests similar to this with deciduous fruits, it is highly probable that large and small nursery trees of apples, pears and other fruits if taken from the same nursery rows of the same age and of the same variety on the same seedling stocks (unselected) would react in the same way.

Cause of Different Tree Sizes

Let us now inquire as to the probable reason for this difference. Is it due to a variation in the variety or the character of the buds used, to variations in the soil, or is it possibly due to differences in the seedlings used as stocks? The buds in the tests at the Citrus Experiment Station were from trees on which careful records had been kept for several years and were selected as standard types. Further than this, trees of three varieties reacted the same. The trees on the San Marino Ranch were not grown from buds taken from what we know as record trees, but were chosen from what were known to be good Valencia trees. It does not, therefore, seem to be possible to attribute this difference to variations in the buds used.

It can scarcely be due to variation in soil or local tree environment as the nursery was on uniform soil and the trees were only a foot apart, and when they were transpanted into new locations in the permanent grove they retained their relative rank of size. It is not thought to be due to unsatisfactory bud unions or diseased roots as all trees used in the experiments were carefully examined and appeared to be normal in these characters.

As the writer analyzes the data, the effect would seem most likley to be due either to variations in the character of the stocks, or to stunting of certain seedlings due to crowding in the seedbed or nursery. It is believed by some growers that trees stunted by underfeeding or ill treatment never entirely recover their full vigor, but the writer knows of no definite evidence supporting this theory while in opposition to it many instances can be cited of groves that have been nearly killed by neglect, such as lack of fertilization and irrigation that on being given good treatment have apparently fully recovered and produced good orchards. True, some orchards so injured by neglect never do recover entirely, but there is of course a limit beyond which ill treatment cannot be carried. All in all it seems most likely that the variation in trees such as we are discussing is due to the use of stocks of different type, in view of the fact that we do know definitely that markedly different types occur among the seedlings used for budding.

The Nursery a Medley of Different Types

A careful examination of the seedlings in any ordinary nursery just before budding will serve to discover many widely differ-

ent types. The differences most apparent at this time are in size of tree, shape and size of leaves, and form of growth. In 1915 the writer and two of his associates selected from a nursery of sour and of sweet seedlings a number of such different types. The tops of each of these were cut off and used for propagating the type and two trees of each have been grown in the variety orchard at the Citrus Experiment Station. They are now seven-year-old budded trees and a lot of trees more variable in character could nowhere be found. Some are still dwarfs not more than 3½ feet high, while others are giants for their age, having already reached from 10 to 12 feet in height. The foliage, flowers, fruit and branching characters vary as greatly as does the growth rate (size), but is not as clearly visible. No one examining these trees at present would ever think of using them as stocks for the same variety in the same orchard. That buds from the same tree inserted on them would grow differently cannot be doubted. Evidence is not yet available from which it can be determined whether it is best to use dwarf, standard, or giant growing stocks in citrus propagation, but it is clearly evident that we do not want them mixed in the same orchard. In practice if a dwarf stock is to be used it should be known and the distance of planting should be gauged accordingly.

While it seems certain that a large share of the variation in size of budded nursery and orchard trees is due to this variation in the growth rate, or size of stocks used, the tests to determine definitely what this effect is, have not yet matured sufficiently to give definite data. In 1920 an experiment was started by Dr. J. T. Barrett in which about 500 sour orange seedlings were carefully numbered, measured and studied, notes of their individual characters being fully recorded. These were then budded with buds taken from a single tree of Washington Naval of standard type. These budded trees have just this last spring been planted in a test grove at the Citrus Experiment Station, and will in a few years give fairly complete information on this point. In the meantime it should be remembered that whatever the cause may be that leads to the development of different sized trees in the nursery, the fact that these trees continue to grow differently in the orchard for at least a considerable period, is pretty thoroughly proven and we are justified in taking steps to avoid the use of the small slow growing trees in our orchards.

Evidence From Variety Orchard

A collection of citrus varieties has been made and planted in a special orchard at the Citrus Experiment Station. Several hundred varieties of oranges, lemons, grapefruits, shaddocks, mandarins, etc., included in this collection, were budded the same spring and planted in the variety orchard at the same time, June, 1917. A study of this orchard at the present time, five years after planting, gives one some idea of the great range of variability we are dealing with when we take seeds of a certain species like sour orange from any source available and without selection. A comparison of the varieties of Citrus grandis, the grapefruits and

shaddocks, shows a tremendous variation in size which is apparently due to the different growth rates of the different varieties. At seven years of age from the buds, some varieties are dwarfs and others are veritable giants, and the same is true among the varieties of sweet oranges, sour oranges and lemons. A comparison, for instance, of the trees of the numerous named varieties of the sweet orange shows that the most of them are of about the same general size and shape—what one might call standard size. Here and there, however, a variety shows up that is far above the standard size or much below it, for instance, both trees of the Carlton orange are far above the standard orange size and are veritable giants. It is not improbable that these giant types are really first generation hybrids, showing the vigor of growth that such hybrids are well known to show commonly (heterosis). Whatever may be the cause of the different rates of growth shown by the different varieties, it cannot be doubted that seeds taken from them would produce seedlings showing like difference, and therefore this demonstration of the different sizes of trees in this orchard strengthens our thesis that stocks must be selected for the characteristics we desire.

How Stock Affects Scion

That the stock does profoundly influence the scion is too well known to require a detailed discussion. The size of the tree is most frequently affected and in some cases, as with the apple and pear, orchards are frequently grown of dwarfed trees produced by the use of stock that cause dwarfing. The Eureka lemon on trifoliate orange stocks in our experiments at Riverside have produced dwarfed trees regularly of not more than one-fourth the volume of comparison trees of the same variety on sour, sweet and grapefruit stocks. The Washington Navel is also slightly dwarfed by the trifoliate orange stock, while the Valencia is fully up to standard size.

A similar reciprocal effect of scion on stock is also sometimes produced. When a vigorous evergreen orange top such as Valencia or Washington Navel is budded on a trifoliate orange stock which is a slow growing deciduous tree, the stock grows more rapidly and much larger than normally and over-grows the orange scion.

Vigorous growing stocks may lengthen the juvenile period of the tree before fruiting begins, while slow growing stocks tend to shorten this juvenile period, though producing a smaller tree. The trifoliate orange stock though generally producing rather smaller trees than the sour or sweet stocks, tends to bring the trees into earlier bearing. The stock is also known in many cases to influence the cold resistance and disease resistance of the scion. While the fundamental reason why root stocks affect scions in a certain way is not well understood, it seems that the most common changes observed are usually connected with vigor of growth, or rate of growth which is an inherent character varying in different seedlings of any species. A vigorously growing stock apparently supplies the scion with abundant moisture and nutritional salts

from the soil, thus stimulating a maximum growth, while a slow growing stock has the opposite effect.

If we are correct in assuming that the growth rate of the stock is likely to have an effect on the scion, and this seems certainly to be the case, then it seems that the use of seeds indiscriminately from different seedlings is to be condemned as bad policy.

The Selection and Propagation of Stock Varieties.

In cases where we know what species is likely to be the best stock, then our further task, it seems to the writer, is to find the individual that possesses the most nearly ideal stock characters and produces regularly the best and most uniform lot of seedlings. When such an individual is found it should be given a varietal name and propagated for the sole purpose of furnishing seeds to grow stocks. Only by some such methods as this can we arrive at any certainty as to the type of stock used.

It may be argued that when one good stock tree is found, budding stock can be grown from cuttings getting thus a maximum uniformity. This would be true in cases where cuttings are known to make good stocks, but in most tree crops such as citrus and pomaceous fruits, it has not yet been demonstrated that cuttings produce good stocks, and in general the evidence is against their use.

In citrus fruits where parthenocarpy is common and a considerable number of the seedlings are direct developments from embryos that spring from the nucellus tissue of the mother plant, a much larger proportion of the seedlings will come comparatively true to the type of the parent than in other common fruits where all embryos arise from a fertilized egg cell. In many cases of radical citrus hybrids such as the citrange (sweet orange x trifoliate orange) and the tangelo (tangerine x grapefruit) it has been found that the seedlings come nearly true to the mother variety in type of tree and fruit, showing almost as little variation as bud propagated trees. It is probable in such cases that the seeds develop without fertilization and that all of the embryos are parthenocarpic. In citrus fruits, therefore, the seedlings of stock varieties will likely be found to come more nearly true to type than in other fruits. The writer believes, however, that the principles will be found to apply just as directly to other fruits as to citrus and that its application in such cases is just as important as in citrus. As cited previously in this article he has in another place called attention to the great variation in size of seedlings of the French cider apples that are now so generally used as stocks for the apple. A confirmation of this view has come to his attention through a recent letter (Nov. 1, 1922, to Director B. H. Crocheron) from Mr. Hermon Baade, one of the writer's associates in the University of California, who is traveling in Europe. Mr. Baade writes, "I do not think that I have told you about the work that is being done at the East Malling Experiment Station in Kent, England. They are working on the variation in root-stocks of apple trees. The director of the Station told me that originally they sent to a reliable

French nursery for crab-apple seedlings. These were planted in orchard form, and observed as to growth characteristics. It was found that no two were alike. They differed in leaf, blossom, and character and rate of growth. The next test was to see how a given type of apple scion grew on these different root-stocks. It was found that some dwarfed the tree, while others caused a very vigorous wood-growth. Some caused early fruiting, others very late fruiting of the young trees. So they now are able to tell the farmer which root-stock to use if he wants a dwarfed early fruiting tree, or which would be the proper root-stock for a large, vigorous, later fruiting tree. These stations do not have the money to spend that most of our stations have, but they are doing some very good work, just the same."

Evidently the results obtained by the East Malling Experiment Station with apples corresponds entirely with those gotten by the writer with citrus, and are certainly in entire harmony with what would be expected from our understanding of the laws of variation and the reactions of stocks of different types on scions. In general it can be stated that where perfect congeniality exists between the stock and scion, the size of the scion tends to correspond to the size the stock would normally attain. There are exceptions to this rule that are difficult to explain, but it is of fairly general appication.

In conclusion the writer would state that his studies lead him to believe that the selection of specially good and uniform types of our most important stocks is a field of paramount importance in our principal fruit industries.

Isolation of Uniform Types of Hubbard Squash by Inbreeding[1]

By J. W. Bushnell,[2] *University Farm, St. Paul, Minn.*

FROM the histrical record of the Hubbard squash, it appears that the variety has been more or less a mixture throughout the period of its cultivation. Shortly after its introduction, Burr (1863) and Gregory (1867), described the typical Hubbard, but also implied that there was considerable variation in fruit character at that early date. At present, most of the available strains are, genetically, mixtures. In view of the fact that all varieties and strains of *Cucurbita maxima* are cross-fertile, and that the monœcious character is favorable to cross-pollination, it is not surprising

[1]Published with the approval of the Director as Paper 364 of the Journal Series of the Minnesota Agricultural Experiment Station.

[2]Acknowledgement. This problem was started by R. Wellington in 1914, then in charge of the vegetable investigations at University Farm. The writer took over the work as a graduate problem in 1917 and is indebted to Professor Wellington for the data prior to 1917, as well as for guidance during 1917 and 1918.

that the commercial varieties of this species are largely heterogeneous mixtures.

Variation in the Hubbard is particularly conspicuous in the fruit characters. Variations in size, shape, color, thickness of the edible portion, hardness of shell, and keeping and eating qualities, present a serious problem in production and marketing of the crop. From the plant-breeding viewpoint the problem with the squash is to secure uniform high-quality economic strains from the mixture that makes up the variety.

Certain aspects of the problem have been covered in the extended work of Cummings and Stone (1921). As a part of their work they undertook to determine the degree to which high yield and high quality are inherited characters. In their studies on the inheritance of yield they made selections from high-yielding and low-yielding open-pollinated plants, and paralleled these with selections from high-yieding and low-yielding self-pollinated plants. They have reported the results from the fifth generation of open-pollinated selections, and the third generation of self.pollinating. Selection was effective in both experiments, as is illustrated by the following figures on yield per plant:

	Open-pollinated	Self-pollinated
High-yield selection.	23.3 pounds	21.2 pounds
Low-yield selection.	18.4 pounds	16.4 pounds

Two facts are evident from these data. First, the high-yielding lines produced nearly five pounds per plant more than the corresponding low-yielding selections. Second, the effect of direct inbreeding as carried out by self-pollinating, has been the production of lines that yield approximately two pounds per plant less than the open-pollinated material. This is approximately a 10 per cent decrease in yield due to inbreeding.

In a similar manner Cummings and Stone produced high and low quality strains. Their report covers five years of selection with five strains, two of which were consistently higher in quality than the others.

At the Minnesota Experiment Station, the problem has been attacked from a slightly different angle. The aim has been to secure uniform, high-quality strains, to distribute as improved types of the Hubbard squash. The first phase of the work was an attempt to isolate approximately pure lines by inbreeding. This paper is a preliminary report on the results of this phase of the problem.

The difficulties encountered in self-pollination have been pointed out in an earlier report (Bushnell 1920). In 1914, strains from several commercial sources were planted. The attempts to self-fertilize these were practically unsuccessful; only two selfed fruits matured. Appreciating the difficulty of self-pollinating, the problem was attacked in a larger way in 1915. With material from several commercial seedsmen and greater care in hand pollinating, 47 selfed fruits were secured.

Twenty-nine different types were selected from the 47 for

further inbreeding. In 1916 a total of 58 selfed fruits matured on 20 of the 29 lots. That is, 9 were lost from failure to set fruits. Seed from all the selfed fruits were planted in 1917 and 45 of the 58 were successfully selfed. In addition, two strains, received from commercial growers who had been practicing careful mass selection, were grown and selfed.

At the time of harvest in 1917 many of the lines, inbred for only two generations, were observed to be very uniform in many characters. For a more detailed study in 1918, the number of strains was reduced to 24 distinct types. All 24 were successfully selfed, and have been completely self-fertile since. Twenty-three were strikingly uniform in all readily measurable fruit characters, such as size, shape, color, hardness and thickness of edible portion

However, the plot was small and the number of plants was limited to 24 or less—too few to give conclusive data. A much more extensive test, therefore, was planned for 1919. The number of inbred lines was reduced to 17, but 13 crosses between the inbred lines were included, and commercial lots from six seedsmen. As far as seed and space were available, the lots were grown in systematically distributed triplicate plots of 20 plants to a plot, to give a basis for a significant comparison of yields. At harvest yields from individual plants were taken and the results tabulated statistically. The comparative uniformity of the inbred lines, their first generation hybrids, and the commercial lots, which may be considered as checks, is illustrated in the following table where the coefficient of variability is computed on the weight of mature fruits. In general, the relative variability of other characters is similar to the range of variability in fruit size. For this reason and in order to simplify the presentation, the tabulation here is limited to the data on weight of fruit.

TABLE No. I.

	Strain	Generations inbred	C. V. of weight of fruit	Average weight mature fruits Kilograms	Plots	Plants
Inbred lines:						
	3	4	15.7	6.4	3	48
	4	4	17.1	4.7	3	49
	5	4	15.7	4.4	1	14
	6	4	23.1	4.1	1	19
	8	4	21.0	4.5	1	18
	9	4	26.8	3.1	1	17
	11	4	14.8	7.1	3	52
	12	3	14.5	4.4	2	19
	15	4	10.7	4.3	2	16
	16	4	24.1	5.3	1	12
	17	4	12.4	5.2	1	14
	18	4	17.5	4.4	2	27
	19	4	14.1	4.5	3	50
	20	4	18.4	2.4	3	50
	21	4	12.1	4.6	3	47
	23	1	19.9	9.4	3	52
	24	1	20.5	5.3	3	37
F_1 hybrids:						
	3 x 13 x 12		16.5	5.1	3	42
	3 x 15		17.6	4.6	2	26
	11 xx 19		17.0	6.3	3	49
	11 x 24		19.4	7.6	3	56
	12 x 19		15.9	4.2	2	21
	18 x 12		14.2	3.6	1	8
	18 x 15		12.4	3.7	1	9
	18 x 23		13.6	3.6	1	8
	20 x 12		16.3	4.2	3	54
	20 x 15		16.9	4.1	3	47
	20xx17		12.5	4.0	1	7
	21 x 11		18.1	5.2	3	43
	21 x 19		16.3	4.7	3	43
Commercial check lots:						
	A		22.9	6.0	1	15
	B		27.5	4.7	1	19
	C		34.2	7.7	1	19
	D		18.3	6.5	1	19
	E		29.6	5.3	1	16
	F		24.6	7.7	3	40

Twelve of the 17 inbred strains have a coefficient of variability below 20 per cent, while only one of the commercial lots produced fruit of equal uniformity of size. The first generation hybrids were in all cases from crosses between parents having relatively low coefficients of variability, so the hybrids were correspondingly uniform.

Comparing the yields of the more uniform strains with the yields of the checks and the F_1 hybrids, it is evident from Table II that the uniform lines, inbred in most instances for four generations, showed only a very small decrease in yield from inbreeding.

TABLE NO. II.

	Strain	C. V. of weight of fruit	Yield per plant Kilograms	Generations inbred
Inbred lines:				
	3	15.7	12.4	4
	4	17.1	12.1	4
	11	14.8	10.9	4
	19	14.1	11.6	4
	20	18.4	10.5	4
	21	12.1	12.3	4
Average			11.6	
	23	19.9	15.6	1
	24	20.5	10.7	1
F_1 hybrids:				
	3 x 12	16.5	12.2	
	11 x 19	17.0	13.0	
	11 x 24	19.4	12.8	
	20 x 12	16.3	12.1	
	20 x 15	16.9	10.7	
	21 x 11	18.1	12.8	
	21 x 19	16.3	11.9	
Average			12.2	
Commercial check lots:				
	A	22.9	11.9	
	B	27.5	10.6	
	C	34.2	11.6	
	D	18.3	15.0	
	E	29.6	13.3	
	F	24.6	11.1	
Average			12.3	

Only the strains grown in triplicate lots, and, therefore, having more significant average yields, are included in the above table. Considering the inbred lines as a group, their average yield is less than five per cent lower than that of the commercial checks. And their first generation hybrids produced very nearly the same yield as the checks. These results are in close agreement with the results of Cummings and Stone. The inbreeding has isolated uniform strains without marked loss of vigor, and hybrids between these inbred strains show a correspondingly small increase in vigor.

From this evidence it would appear that uniform high quality strains of desirable economic types may be secured by simple inbreeding. The small decrease in yield is more than offset by the advantages of uniformity. This is illustrated by the recent popularity of strain 20, which, as shown by Table II, was the lowest in yield of the inbred lines in 1919.

The possible economic value of some of the strains was evident as early as 1918, so in addition to the critical tests at University Farm in 1919, three strains were distributed in small samples to a limited number of growers and experiment stations. Strain 20, producing very small fruits—average weight in 1919 being 2.4

kilograms—early maturing and keeping well in storage, was reported to be a very desirable type of Hubbard squash.

In 1920 and 1921, this strain was more widely distributed for trial through the cooperation of the Minnesota Horticultural Society and the Minnesota State Vegetable Growers' Association. From a large number of reports it was apparent that this small Hubbard was a desirable type. In 1921 the seed stock was increased and the strain placed in the hands of Minnesota seedsman under the name Kitchenette Hubbard.

From the plant breeding standpoint it is significant that actual results have been obtained from inbreeding. These results from the squash add another bit of evidence as to the value of inbreeding as a plant breeding method in genetically heterogeneous material. Particularly in the vegetable crops are the varieties mixed. The majority of them are normally open-pollinated and from the limited evidence at hand appear to be largely self-fertile. In all these crops there is the possibility of isolating more uniform and more valuable strains by inbreeding methods.

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Time of Flower Primordia Formation in the Onion. (Allium cepa, L.)

By H. A. Jones,* *University of California, Davis, Calif.*, and V. R. Boswell, *University of Maryland, College Park, Md.*

When small onion bulbs commonly known as "sets" are planted in the field for the production of green, bunch, or ripe onions, there is always a large percentage that form seed stalks. This "shooting to seed" is especially undesirable in the production of large, ripe bulbs and is one of the main limitations in production of onions from sets. The very small sets seldom run to seed, but generally speaking, as the size of the set increases the greater is this percentage, until a certain size is reached when 100 per cent of the resulting plants send up seed stalks. Sets weighing approximately one gram or less produce only a very small percentage of seed stalks. As the size of the bulb is increased, there is a gradual

*The senior author planned and carried this project to partial completion while a member of the Horticultural Department of the University of Maryland. The Junior author completed this problem and prepared this paper for publication.

rise in percentage of the resulting plants going to seed. Bulbs weighing 12 grams or above, as a rule, produce plants almost every one of which forms one or more seed stalks.

It was thought that by harvesting at a definite time in the plant's life, perhaps the development of the flower axis might be arrested or entirely prevented; or, that by making certain fertilizer applications, the internal food balance of the onion might be altered so that the growth tendency would be vegetative rather than reproductive.

In order to fertilize intelligently, or be able in any other way to upset the nutritive balance of the bulb, changing the tendency from reproductive to vegetative development, or *vice versa*, it is necessary to know definitely the time at which the flower axis starts to elongate, under natural conditions and normal development. So far as the writers are aware there never has been any study made of the time of flower primordia formation in the onion. There is a very limited amount of information regarding growth and development of any of the bulbous plants to be found in the literature. The consensus of opinion among growers and botanists, with whom the writers have conversed, is that the flower primordia are differentiated in late summer or early fall during the maturation period of the bulb.

The investigations reported in this paper were initiated with the purpose of determining (1) the exact time at which the flower primordia are formed in the onion, and (2) the influence of the date of planting sets in the field on the time of differentiation.

The variety used in these studies was the Yellow Globe Danvers. Seed was planted in the field in the spring of 1921. The product of this planting was studied during the latter part of the growing period, during storage, and after planting the bulbs the same fall and the following spring. The crop matured early in August and was harvested, then stored in an outbuilding in which the onions were subject to a considerable range of temperature and humidity. Onions were taken from storage and planted in the field October 21. These sent out leaves and grew well until early in December. Another planting was made on March 25 following.

The following tabulations show the date of planting and the date and conditions of the bulbs and plants at time of taking samples.

(1) Onion seed planted in the spring of 1921.

A. Samples taken July 16, 1921. The onion plants had formed bulbs averaging 4 to 5 cm. in diameter. The tops were standing erect and in a healthy growing condition.

B. Samples taken August 4, 1921. The plants had matured, the tops had fallen over and were almost completely dried although in most cases the roots were still alive.

C. Samples taken October 17, 1921. Onions had been in common storage mentioned above since early in August.

(2) Onion bulbs which had matured in August and had been placed in storage were planted in the field on October 21, 1921.

A. Samples taken December 3, 1921. Due to the excellent growing conditions prevalent from the time bulbs were planted, they had made a gradual and continual growth up to this time and the tops were a foot or more in height.

B. Samples taken March 28, 1922. The tips of the leaves for some distance back, had been killed during the winter, but the leaves continued to grow and at this time had a top growth averaging 12 to 15 inches.

C. Samples taken April 11, 1922.

(3) Onions which had been stored all winter were planted in the field March 25, 1922.

A. Samples taken April 13. The plants were not nearly as large as the fall-planted lot pulled on March 28. Some of the plants that had the flower axis well formed had leaves only 3 to 4 inches in length.

B. Samples taken April 20.

In taking samples a cube was cut which contained a small portion of the upper part of the stem plate and 4 to 5 mm. or more of the base of the leaves. This material was killed and fixed in medium chromo-acetic acid for 24 hours and then washed for an equal length of time, dehydrated with alcohol, infiltrated and mounted in paraffin. Longitudinal sections were cut through the growing point of the bulb 8 to 10 microns in thickness. The sections were stained in safranin and then mounted in Canada balsam.

A careful study of the sections cut from material killed on July 16, August 4, October 17 and December 3, 1921, failed to discover any floral structures.

The first evidence of flower development was found in bulbs which were planted in the field October 21, 1921, and killed on March 28 the following spring. Twenty different plants were sectioned and studied, some showed no signs of floral development while others had flower stalks 3 to 4 mm. in length. This wide variation in floral development does not necessarily imply a wide range of time in differentiation.

The time of taking the samples on March 28, and possibly 3 to 4 days earlier, was when the greater part of the differentiation took place. When once formed, the young flower stalks elongate very rapidly and soon appear through the opening in the upper part of the surrounding leaf sheath. The onions used in this work were sufficiently large to definitely insure their going to seed. Most of the bulbs had several growing points and when examined on April 11, each growing point in the bulbs studied was found to contain a developing flower head. The flower axis appears to be located at no particular point with reference to the number of leaf sheaths, or scales, which surround it. There was a great variation in the stage of development of the flower stalk between the various

individuals, but there was no apparent correlation between the length of flower stalk and the leaf development.

The first samples from bulbs planted on March 25 were killed on April 13. This lot had already reached the same stage of floral development and presented the same wide range in condition as previously noted in the fall planted lot which was killed on March 28. The longest flower stalks were 4 to 5 mm. in length. A second study of spring planted bulbs was made April 20. Thirty-nine growing shoots were dissected and the enclosed flower shoots were measured. There was a range in length of flower stalk from one-fourth inch to three inches, indicating a variation in the time of differentiation and a very rapid growth.

From the foregoing observations we may concude that the flower primordia of the onion are differentiated early in the spring under conditions prevailing at College Park, Maryland, regardless of whether the bulbs are planted in the fall or early the following spring, after having been kept in storage over winter. There is apparently no correlation between the stage of vegetative development of the plant and the time flower primordia are differentiated. The factors that determine the time of differentiation are either high temperature or length of day, or the possible interplay of these two factors. Fall planted bulbs may show development of flower axis before those planted in the spring of the year. The differences in time of appearance of the flower axis in the fall and spring planted bulbs are entirely a matter of date of spring planting. The later the planting, naturally, the later in the year will be the time of appearance of the flower stalk. An important by-product of this work is the observation that fall planted bulbs, which made a luxuriant foliage development before the differentiation of flower primordia, produced uniformly taller and heavier seed-stalks with a heavier set of blossoms, than was obtained from the spring planted bulbs. These observations and conclusions give us a foundation upon which to plan methods of handling and fertilizer treatments in an attempt to inhibit flower primordia formation and flower development in the onion, at least in the smaller sized bulbs or sets where the tendency to form seed stalks is less than in the case of larger sized bulbs.

Fruit Setting on the J. H. Hale Peach

By C. H. Connors, *Experiment Station, New Brunswick, N. J.*

BORNE on the wave of what was, up to that time, probably the most extensive program of advertising any horticultural variety ever received, the million dollar peach, J. H. Hale, was widely planted, without any trial plantings to test its adaptability to various environmental conditions. And yet I very much doubt if any wide test as usually made would have disclosed the chief fault of this variety. Our own trial was, perhaps,

typical. A few trees were set in a variety test block, surrounded by trees of other varieties, and when mature bore good crops.

This variety has many good points to recommend it as a commercial peach. In tree habit it is rather dwarfish, making it an economical tree to handle in orchard operations. Its fruit is large and the tree can mature relatively large crops without much thinning. The skin is tough, almost as smooth as that of a nectarine and attains a very high color, up to 100 per cent, a week or 10 days before the fruit is ripe. The flesh is very firm, permitting handling with little danger of bruising. The quality is superior to that of its probable parent, Elberta.

As soon, however, as the early planted blocks came into bearing in some peach sections, it was found that something was wrong with the fruit setting habit of this variety. Instead of bearing full crops of good sized peaches, only a few full-sized specimens developed, the rest being small and insignificant. The peculiar thing about it is that in some orchards in certain sections, this variety will produce a full crop of large, fine peaches, while in other orchards only a short distance away a light crop, or no crop at all, would be borne. The freeze of 1921 injured the blossoms of nearly every variety in South Jersey, and yet, in some orchards, good crops were secured on J. H. Hale while other varieties bore practically no crops.

These small fruits called "buttons" have been observed previously upon a number of varieties, chiefly of the so-called Persian group, or Crawford type. Blake, Farley, and Connors (1) have noted it on St. John, while Palmer (7) has noted it on Bilmeyer, Brigdon, Early Crawford, Richmond and St. John. These buttons behave as if fertilized as unfertilized blossoms drop very shortly after petal fall. They develop normally for about four weeks after blooming, and then the growth of the fruits proceeds at a much retarded rate. On July 3, 1922, the buttons on J. H. Hale measured three-fourths inch in diameter while normal fruits measured 1¼ to 1½ inches in diameter. The buttons ripen a few days to a week later than normal fruits and are much undersized, often poorly colored, and somewhat flattened like the fruits of a tree infected with little peach. The flavor is flat and insipid. The stones are hard and nearly normal in shape, but having no kernel. The embryo appears to develop for about six weeks and then ceases to grow.

The causes of this condition have been variously ascribed. Blake, Farley, and Connors (1) stated that they believed it due to winter injury to the peduncle. Palmer (7) believed it due to improper pollination due to the weak pollen of early varieties and that the reason for the fruit hanging until the normal period of maturity for the variety is the poor crop borne by the tree. Parthenocarpic fruits have not been found in the peach, although Ewert (4) endeavored to produce such fruits.

In the course of breeding operations with peaches in 1920, two seedlings of Belle self-pollinated were covered to secure the F_2 generation. A study of the flowers of these two seedlings showed a peculiar condition of the anthers, in that they were very

pale in color and when the period of dehiscence came, no pollen was evident. The blossoms on these trees were left to self-pollinate and set only a few fruits each, and the conclusion was drawn that they were almost if not totally infertile. The occasional fruit was due probably to a few fertile anthers appearing in the flowers from which they developed. In 1921 and 1922 more critical examinations were made of the seedlings and some 100 commercial varieties grown on the horticultural farm, with the result that of all the commercial varieties, J. H. Hale was the only one that appeared to have this condition of stamens (although occasional flowers were found in this condition on Slappey, Foster and Fitzgerald) while a number of seedlings were found to have this condition, as follows: Belle self-pollinated, 5.7 per cent; Bell X Elberta, 1.5 per cent; Elberta self-pollinated, 7.5 per cent; Elberta X Belle, 2.2 per cent; Elberta X Greensboro, 2.7 per cent; Belle X Greensboro, 1.5 per cent. These percentages are not for the entire populations as a large number of seedling trees had been removed previously because unworthy, and a large proportion of the infertile individuals have not yet borne sufficient fruit to give a test and so remain in the orchard. Trees of J. H. Hale enclosed in tents have set only 5 per cent of normal fruits when allowed to self-pollinate.

The conclusion was drawn that one cause of the uneven setting of fruit on J. H. Hale was due to lack of pollen production.

Peaches in the United States and Canada have always been considered self-fertile. Close (2) and Wiggan (9) bagged twigs of various important commercial varietes and found them self-fertile. This has been borne in our own breeding work where upon trees enclosed in cheese-cloth tents certain branches left unmolested set just as good or better crops than those which were emasculated and hand pollinated.

On the other hand, Coote (3) reported that in the greenhouse peaches failed to set unless pollinated with a brush or by bees. He found some differences in the amount of pollen produced by various varieties. However, this failure to set fruit can probably be ascribed to the lack of strong air currents in the greenhouse. While the wind is not believed to be a factor in the carrying of pollen, it probably plays an importnat part in moving or swaying the stamens so that the anthers come in contact with the stigmas. Ewert (5) claims that self-fertility occurs sparingly among the varieties of peaches in Germany.

One would naturally assume that an infertile peach variety would soon be eliminated from the commercial list, and it is probably that very few have become varieties of importance. The only case on record is that of the variety Susquehanna, reported by Fletcher (6) as having a tendency to self-sterility, and this variety has been only locally important. Among our seedlings several very promising ones have this fault and have been discarded.

During the blooming season of 1922, special observations were made on the behavior of J. H. Hale and some of the seedlings. No histological examinations have been made as yet, but at the nor-

mal time of the dehiscence of the anthers of J. H. Hale, and some of the seedlings classed as infertile, the anthers were reduced in size, white or pale yellow instead of the normal reddish tint and with shorter filaments. The anthers appeared to be just a mass of tissue, with no spore form. Cultures were made to test pollen germination and normal germination was secured in the case of Belle, Hiley, Elberta and a few fertile seedlings, while J. H. Hale and a few of the seedlings suspected of infertility gave no germination in sugar solutions.

This is believed to be the cause of light fruit setting on J. H. Hale. The good set secured after the freeze of 1921 can be explained on the basis of cross-pollination. The freeze injured the pistils of other varieties, while the stamens were uninjured and furnished a good supply of pollen for the bees and other insects to work with on the uninjured pistils of J. H. Hale. This variety is late in blooming, and its buds open very irregularly, extending the blooming period for about a week longer than most other varieties.

The cases where good crops are set on this variety in a normal year are in all probability due to the location of the trees with respect to possibilities for cross-pollination.

Why the fruit should set, begin to develop and then be retarded in growth requires another explanation. Examinations show that within a period of six weeks after pollination, all development of the embryo ceases, nothing remaining but a shriveled empty seed coat when the stone is formed. If pollination has been accomplished complete fertilization has not taken place. This may be due to the pollen tube being slow in growth so that the tube nucleus enters the ovum at a period too late for fusion The development of the buttons would then be an expression of vegetative vigor. This, of course, is predicated on the possibility of a few blossoms bearing anthers that contain some pollen.

The pollination problem is always taken into consideration in planting an apple orchard, but heretofore, has not been believed necessary with peaches. But, owing to the behavior of J. H. Hale, it is believed that in planting this variety provision should be made of facilities for cross pollination. This is now recommended by Palmer (8). This variety has such marked advantages from a market standpoint, that it will probably continue to be planted. In new plantings, therefore, it is recommended that the blocks be no wider than five rows with some other variety planted as a pollinator. In older plantings where the blocks are larger, every fifth or sixth row should be removed or topworked with another variety or else every other tree in each alternate row should be topworked with some other variety to act as a pollinator.

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Apple Pollen Germination Studies*

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PROCESSES directly or indirectly concerned with the development of variable seed of the apple are of great importance to the horticulturist, except in cases where parthenocarpy is the rule. Strility often plays an important role in modifying the results which the experimenter and practical orchardist would normally expect. To one interested in breeding, this factor becomes even more important. Consequently any indirect and relatively inexpensive method which would give the observer an index as to the compatibility existing between pollen and pistils of one or more varieties of apple, would be of value and might possibly serve as a guide to breeding as well as orchard practices.

Preliminary observations during the spring of 1922 were made by the writer, to determine whether the pollen tube growth or the percentage germination of a variety of pollen, when observed in an artificial germination medium to which a known variety of stigma was added, might be correlated with the facts of sterility observed in controlled crosses. The results of these observations seem worthy of presentation.

This paper includes data on the following points: the pollen tube length of the pollen of various varieties of apple; the effect of the stigma on pollen tube growth; the relation between the variety of stigma and germination of various kinds of pollen; and finally the average percentage of germination of the pollen of different varieties.

LITERATURE

RATE OF POLLEN TUBE GROWTH

The literature does not indicate that pollen will react specifically to a particular variety of stigma in a germination medium.

East, E. M. and J. B. Park, (1918) give a critical review of

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the literature which need not be repeated here. In regard to their own work with tobacco they state, "The evidence of stimulation from the presence of ovules and more particularly of stigmas, is unmistakable, but whether the presence of 'compatible' stigmas or ovules shows an additional stimulation over that due to 'incompatible' stigmas and ovules, is questionable. ....Experiments of this kind are unsatisfactory. They may not be useless, but it seems improbable that any notable increase in knowledge will be obtained by their use until the technique is so improved that the growth curve in artificial media compares favorably with the natural growth curve."

Pollen tube growth within the style, however, has a direct bearing on sterility. Jost (1907) and Correns (1912) found that when a self-sterile plant is pollinated with its own pollen, the tubes are emitted freely, but grow extremely slowly. A cross-pollination on the same plant results in rapidly growing tubes. East and Park (1918), using tobacco, present graphs showing that with selfed plants, which are self-sterile, the growth is apparently normal but so slow that after fourteen days, in one case, the pollen tubes were only half way to the ovary. In compatible crosses the growth starts at about the same rate as in selfed pistils, but the speed continually increases until fertilization takes place, usually after from three to five days. Dorsey (1919) has suggested that in the plum, sterility, in certain cases, may be due to the fact that weather conditions may retard tube growth and abscission of the style occur before the tubes have passed the abscission zone. Our own work with the plum indicates that circumstances comparable to those noted by Jost, Correns, and East and Park also are operative.

What evidence we have indicates that apple pollen tubes will behave similarly. Knight (1917) found that Rome Beauty x Rome Beauty pollen tubes were still on the way to the egg after 120 hours, at which time the egg had begun to disintegrate, while Jonathan pollen tubes had effected fertilization in 48 hours. It seems reasonable to believe that the same condition will be found to exist in other varieties of apples in which self and cross-sterile relationships exist.

Pollen Germination Tests

Apple pollen germination tests seem to indicate that apple pollen is not so difficult to work with as the pollen of tobacco, the grasses, clovers and many others, which have proved to be very difficult. Eckerson (1917) obtained tubes 10 mm. in length with Rome Beauty pollen in a 3 per cent fructose solution to which a trace of asparagin had been added. The length of the Rome Beauty style is 7 mm. Growths of 5 mm. after 24 hours were occasionally observed in our own cultures, and the large numbers of callose plugs formed in the tubes indicate that the condition observed was something approaching normal growth.

Many kinds of media have been used to germinate apple pollen, though the rate of tube growth has not always been mentioned.

Auchter, (1921) obtained best results with a 10 per cent cane sugar solution though 2 per cent and 5 per cent solutions gave good germination. Knight (1917) obtained best results with an 8 per

cent and 10 per cent cane sugar solution, while Eckerson (1917) found a 3 per cent fructose solution to be preferable. Martin and Yocum (1918), Sandsten (1909) and Adams (1916), obtained best results with 2.5 per cent, 3 per cent and 5 per cent cane sugar solutions, respectively. Knight (1917) and Martin and Wocum (1918), found that apple pollen germinated fairly well in distilled water, and Martin and Yocum state that apple pollen germinates as well if not better on a moist animal membrane than in a 2.5 per cent sugar solution. Knowlton (1922) found 30 per cent and 40 per cent germination in 15 per cent and 17 per cent cane sugar solutions, respectively, and 30 per cent germination in 25 per cent and 28 per cent solutions. The temperature used in all cases was 25°C.

The question of the stimulative action to the germination and growth of pollen by the addition of pieces of stigma, or other parts of the same or other plants, to the germination medium, has received more attention with plants other than the apple, (Richer, 1902, Molisch, 1893, Lidforss, 1896, Miyoshi, 1894, East and Park, 1918).

Alderman and Knight (1917) in some preliminary experiments, apparently did not find any stimulation when measured by per cent of germination from the addition of apple stigmas or the stigmas of several other plants, when these were added to media used for the germination of apple pollen. Knowlton (1922), however, states that he has obtained stimulation and even chemotropism by the addition of a portion of stigma.

EXPERIMENTAL METHODS

Germination Medium Used

In tests carried on at Minnesota, the aim was to obtain a medium which would not only permit of germination, but also induce growth of the tubes simulating normal growth. Various solutions of cane sugar were tried and an 8 to 10 per cent solution gave good results, although not all that was desired. Gelatine added to the solutions seemed to increase markedly the percentage of normal tubes obtained, and a medium containing 5 per cent cane sugar and 1 per cent gelatine by weight was finally selected as the best. In testing the solutions, a stigma of the same or of a different variety than that of the pollen to be germinated, was added to the hanging drop in a van Tiegham cell at the same time that the pollen was added.

The criteria used in selecting the medium were—length of tube attained, number of callose plugs formed, (which is directly correlated with tube length) and appearance of the tube after a 24 hour period. The time allowed for germination and growth was 24 hours. Laboratory temperatures ranging from 60° to 70° F. prevailed, the higher temperatures occuring during the later tests.

Methods Used in Determining the Effect of Stigmas on Pollen Germination and Tube Length

In conducting the experiments the procedure was about as follows. Twigs of each variety to be tested, bearing several clusters

of bossoms, were placed in water in the laboratory, the blossoms allowed to open and the anthers dehisce. This was necessary in order that the stigmas and anthers would not become contaminated with foreign pollen, and in order that all the blossoms of the various varieties would be at approximately the same stage of maturity. (Auchter, 1921). The cultures were made by removing a small quantity of pollen—50 to 150 grains—from the anther with a dissecting needle and placing it on the surface of a drop of the solution. Control of the number of grains was necessary in order to faciliate the measurement of the pollen tubes, which was very difficult when large masses of tubes were formed. A "receptive" stigma was removed from an open blossom, by snipping it with sharp forceps from the style just below the fluted papillate surface, and placed in the drop. The drop was then inverted over a hard rubber or glass ring forming the van Tieghem cell and ordinary precautions taken to prevent evaporation and to give the cultures uniform conditions for growth. In this way cultures containing the same variety of pollen but a different variety of stigma in each, were made. Other series with different varieties of pollen, but similiar varieties of stigmas were used. Check cultures without stigmas were used in each pollen series. The cultures were kept at laboratory temperature (which varied from 60° to 70° F.) for 24 hours, after which the cover slip and drop were removed from the ring, and the stigma and pollen grains with their tubes were mounted by placing the whole on a drop of lactic acid. Only slight pressure was necessary to crush the stigma and cause the cover slide to lie flat. This made a very satisfactory semi-permanent mount, stopped any further growth, and made it relatively easy to measure the tube lengths. A duplicate test was run after the first had been completed, using the same varieties as much as possible and inserting new ones as the material became available. The time required to make the cultures and mounts was from May 15 to May 20. A longer time was required to analyze the material.

Tube lengths were measured by means of an ocular micrometer and mechanical stage. At least five normal appearing tubes were measured in each mount and averaged. Germination counts were made at the same time, and the following criteria were observed in the counts—50 to 100 grains were counted in each mount and the percentage of germinated grains calculated. The following categories of grains were classed as not germinated:

1. Shrunken and shriveled grains without any apparent cytoplasm.

2. Small round grains with cytoplasm, but having a diameter of only one-half to three-fourths the diameter of a normal grain. These swell slightly and occasionally burst.

3. A small class of grains which average much larger than the normal grains and are filled with cytoplasm. These do not ordinarily produce tubes, or if so, are abortive.

4. Grains of normal size and apparently normal contents which produce tubes that burst after attaining a length of approximatey two pollen grain diameters, more or less.

TABLE I.

Length in Millimeters of Pollen Tube Growth of Different Varieties in Different Stigma Cultures

Pollen Variety	Stigma Variety: Check—No stigma added		Stayman Winesap		Hibernal		Patten		Jonathan		Colorado Orange		Delicious	
Stayman Winesap	0.7	0.6	0.5	1.5	0.9	0.3	0.4	0.9	0.8	2.1	1.0	1.9	1.6	1.6
Hibernal	0.4	0.7	1.0	...	0.7	3.1	0.6	2.1	2.4	2.0	2.4	3.1	1.3	1.8
Patten	0.3	1.3	3.0	...	0.6	2.4	1.3	2.5	1.3	2.8	0.7	0.7	2.7	3.0
Jonathan	1.2	1.4	3.1	...	1.5	2.6[2]	0.6	2.5[2]	2.3	1.7	2.5	3.6	1.7	2.1
Colorado Orange	...	0.6	...	...	...	1.8	...	1.8	...	0.7	...	2.6	...	2.0
Delicious	2.1	2.6	2.2	...	2.3	3.3	2.9	1.9	3.1	2.4	2.7	2.7	2.3	2.3
Rome Beauty	1.2	2.3	2.1	...	1.1	2.4	1.3	2.2	1.7	2.5	3.0	1.4	3.2	1.3
King David	0.9	0.7	1.7	...	...	0.6	...	2.5[2]	...	1.9	2.2	2.9	...	2.3
Oldenburg	1.9	0.8	2.8	...	1.9	...	0.9	1.8	2.7	2.3	2.6	2.2	2.0	2.0
Wealthy	1.7	0.6	2.4	...	1.0	3.3	0.6	2.0	1.3	2.4	2.3	3.9	0.8	2.8
McIntosh	1.0	0.4	2.7	...	1.6	1.8	2.3	1.8	1.8	2.3	2.7	2.3	0.4	2.3
Gilbert Winesap	0.6	1.0	...	1.9	0.7	...	0.9	...	1.2	...	2.0	1.5	1.2	0.7
Anisim	...	0.8	...	...	...	0.5	...	3.4	...	2.8	...	2.8	...	2.5
Gano	...	0.4	...	...	...	3.1	...	2.6	...	2.0	...	1.2	...	2.8
Tompkins King[1]	0.5	...	1.9	...	1.3	...	1.6	...	2.0	...	2.1	...	2.2	...
Northwestern Greening	1.4	...	2.6	...	1.2	...	1.7	...	2.3	...	3.0	...	0.9	...
Winesap	0.2	...	...	...	1.8	...	1.9	...	2.6	...	1.6	...	0.6	...

Pollen Variety	Stigma Variety: Rome		King David		Oldenburg		Wealthy		McIntosh		Gilbert Winesap		Malinda	
Stayman Winesap	0.2	2.8	1.8	1.6	0.9	2.7	1.5	2.9	2.0	3.6	0.8	0.6	0.4	1.5
Hibernal	0.6	...	1.6	2.8	0.5	2.3	0.3	1.7	2.6	3.7	0.8	...	1.0	3.0
Patten	1.8	...	1.8	...	3.6	2.7	2.3	3.6	4.0	2.1	2.6	...	1.5	...
Jonathan	1.4	...	2.0	2.4	2.0	2.5[2]	2.1	2.4	2.5	2.4	2.9	...	2.2	1.6
Colorado Orange	...	...	...	1.9	...	1.8	...	1.0	...	2.5	...	...	...	1.9
Delicious	2.6	...	2.4	2.5	2.3	2.6	3.7	3.2	3.4	3.5	1.6	...	2.5	2.6
Rome Beauty	2.0	2.8	1.7	0.6	2.4	1.7	2.7	1.5	3.1	...	3.2	...	1.7	1.9
King David	2.7	1.7	2.1	1.8[2]	2.6	1.9	2.0	3.0	2.4	2.6	...	...	...	2.7
Oldenburg	2.8	...	2.4	1.4	3.1	1.6	4.0	2.0	3.8	...	2.1	...	1.6	2.2
Wealthy	2.3	...	1.1	2.1	2.0	2.5	2.2	2.9	3.7	3.3	1.8	...	1.9	2.4
McIntosh	0.6	...	2.2	2.2	3.2	2.5	1.9	3.1	2.8	2.2	1.2	...	2.2	2.5
Gilbert Winesap	0.7	2.5	1.5	...	1.7	2.0	2.0	0.8	1.4	3.6	1.1	0.2	1.5	...
Anisim	...	...	...	2.1	...	2.9	...	2.8	...	2.9	...	...	...	2.2
Gano	...	...	...	2.5	...	2.2	...	2.0	...	2.2	...	...	...	2.4
Tompkins King[1]	3.9	...	2.3	...	1.7	...	2.5	...	2.1	...	1.5	...	1.7	...
Northwestern Greening	3.3	...	1.5	...	3.5	...	3.1	...	2.7	...	3.5	...	1.9	...
Winesap	2.8	...	1.6	...	2.7	...	2.4	...	2.1	...	4.1	...	1.6	...

Pollen Variety	Stigma Variety: Anisim		Gano		Tompkins King[1]		Northwestern		University		Winesap
Stayman Winesap	1.5	...	2.1	1.3	1.4	0.4	2.4	1.8	2.1	2.2	...
Hibernal	1.4	2.9	1.3	2.8	1.1	...	1.9	3.5	1.5	1.7	...
Patten	2.1	3.0	2.3	...	3.3	...	3.0	2.9	2.0	2.6	...
Jonathan	3.2	1.6	2.7	3.4	4.2	...	1.9	2.9	2.4	3.2	...
Colorado Orange	...	1.5	...	2.8	...	...	...	2.5	...	2.7	...
Delicious	...	4.0	2.2	3.0	2.4	...	2.4	3.5	2.5	3.2	...
Rome Beauty	2.7	3.1	1.7	2.1	2.8	...	3.1	1.6	2.8	2.5	...
King David	...	3.0	1.3	2.2	2.5	...	1.9	3.2	0.9	2.5	...
Oldenburg	...	2.0	...	3.7	...	...	...	2.7	2.0	2.3	...
Wealthy	...	2.3	1.8	3.2	2.4	...	2.5	2.3	0.9	2.1	...
McIntosh	...	1.4	3.4	3.2	2.1	...	4.1	2.1	3.3	1.8	...
Gilbert Winesap	...	...	1.6	1.2	0.7	1.2	1.5	3.1	1.4	1.2	1.3
Anisim	...	2.5	...	4.0	...	...	...	2.0	...	2.1	...
Gano	...	0.4	...	2.0	...	...	...	2.3	...	2.2	...
Tompkins King[1]	...	...	0.9	...	0.8	...	2.4	...	1.5	...	...
Northwestern Greening	...	...	3.2	...	2.2	...	3.7	...	2.1	...	...
Winesap	...	...	0.6	...	...	...	0.4	...	2.1	...	1.2

[1]Probably not true to name.
[2]Average of two determinations.

Presentation of Data

Pollen Tube Length

Table I. presents the results of the experiment to determine the pollen tube length attained by various varieties of pollen in different stigma cultures. The vertical column includes the names of the varieties of pollen used and the horizontal row of names the stigmas. The first column of figures under each horizontal heading is the average growth of pollen tubes in millimeters in the first test, and the second column gives the results of the second test.

A cursory glance at the body of the table shows many wide discrepancies between the duplicate measurements, and shows clearly that single or duplicate determinations, are subject to wide variability. One may find instances where apparently differences in pollen tube growth may be significant. Delicious pollen tubes grew 3.45 mm. in length in Wealthy and McIntosh stigma cultures during the 24 hour period, while in Delicious and King David cultures the growth was 2.3 mm. and 2.45 mm., respectively, or a difference of 1 mm. McIntosh pollen grew tubes measuring 3.3 mm. in length in a Gano stigma culture and only 1.7 mm. in a Hibernal culture. The duplicate determinations as a whole, however, are so variable that if differences in pollen tube growth of a variety of pollen in two or more stigma cultures are significant, it would require very

Table II.

Average Tube Length after a 24 Hour Period of all Varieties of Pollen as Affected by a Variety of Stigma

Stigma Variety	Number of Different Pollen Varieties	Average Tube Length in Duplicate Observations: First Test mm	Average Tube Length in Duplicate Observations: Second Test mm	Percentage Variability in Growth 2nd over 1st	Total Number of Observations	Average Tube Length mm
Check—No stigma added	11	1.09	1.12	2.7	28	1.02
Hibernal	9	1.30	2.01	35.3	27	1.64
Patten	9	1.21	1.98	33.9	28	1.79
Gilbert Winesap	..	....	....	....	15	1.87
King David	9	1.92	1.92	0.0	27	1.91
Delicious	9	1.78	2.14	16.8	23	1.91
Malinda	8	1.69	2.20	23.1	25	1.94
Tompkins King*	..	....	....	....	14	1.96
Jonathan	9	1.93	2.39	19.2	26	2.05
Rome Beauty	..	....	....	....	18	2.08
Stayman Winesap	..	....	....	....	14	2.10
University	11	1.98	2.30	13.9	28	2.14
Anisim	..	....	....	....	17	2.27
Oldenburg	11	2.21	2.27	22.6	29	2.30
Gano	9	2.01	2.49	19.2	26	2.31
Wealthy	11	2.25	2.46	8.5	28	2.34
Northwestern Greening	10	2.47	2.69	8.1	27	2.50
McIntosh	10	2.75	3.00	8.3	27	2.70

*Probably not true to name

careful and exact determinations under strictly comparable conditions to demonstrate them conclusively. Unfortunately, this could not be done at the time, since these observations were made only with the idea of determining if such differences occur, and a study of as many varieties as possible was necessary.

It is interesting, however, to compare the difference in growth of the various varieties of pollen taken as a group as affected by a particular variety of stigma, and again the rate of growth of a particular variety of pollen irrespective of the variety of stigma culture in which it is grown.

Effect of Stigma on Pollen Tube Growth

In Table II, the average tube length attained by various varieties of pollen in each varietal stigma culture, is presented. In the first two columns of averages, only those pollen cultures which were used in both tests are included. The last column is the average total growth obtained in both tests, including those which were not duplicated.

These data show that the addition of any of the varieties of stigmas used, to a pollen germination medium, does increase the growth attained during a 24 hour period. Evidently, also, the stigmas are slightly different in respect to their influence on the growth. There can be little question that McIntosh stigmas are better than Patten or Hibernal stigmas, on the average, since the former variety has consistently stimulated greater growth of the pollen tube. Finer distinctions than general groups cannot be drawn, however, since careful methods would need to be employed to show that the smaller differences are significant.

It is noted from Table II, that there has been an increase in growth in the second over the first test of approximately 15 per cent, on the average, indicating that conditions were more favorable to growth during the latter test. This is probably a result of temperature fluctuations which could not be controlled. The increase has been quite variable, however, which may be interpreted in various ways; certain stigmas may influence the growth of pollen tubes more at one temperature than do others, or the differences represent the natural variability to be expected in a test of this nature, due either to the pollen or stigma or both. Both may be true in part.

However, these data indicate, with but little question, that stigmas of various varieties of the apple stimulate pollen tube growth in a germination medium, and that certain stigmas, such as McIntosh or Northwestern Greening, stimulate tubes to longer growth in a given period of time than do others, as for example, King David, Gilbert Winesap, or Patten.

TABLE III.

Average Growth During a 24 Hour Period of Each Variety of Pollen Regardless of the Stigma Culture Used.

Pollen Variety	Number of Different Stigma Cultures	Average Tube Length in Duplicate Observations: First Test mm.	Average Tube Length in Duplicate Observations: Second Test mm	Percentage Variability in Growth 2nd over 1st	Total Number of Observations	Average Tube Length mm.
Gilbert Winesap	11	1.30	1.70	23.5	29	1.30
Stayman Winesap	18	1.20	1.70	29.4	37	1.49
Hibernal	15	1.20	2.50	52.0	34	1.86
Winesap	..	....	....	....	17	1.89
Tompkins King*	..	....	....	...	18	1.90
Colorado Orange	..	....	....	....	15	1.96
Gano	..	....	....	....	15	2.14
Oldenburg	12	2.40	2.10	12.5	30	2.17
King David	10	1.90	2.20	13.6	30	2.19
Wealthy	14	1.80	2.50	28.0	33	2.21
McIntosh	14	2.20	2.10	4.5	33	2.26
Rome Beauty	15	2.30	2.00	13.0	34	2.28
Jonathan	15	2.20	2.40	8.3	37	2.39
Patten	12	2.60	2.50	3.8	31	2.40
Northwestern Greening	..	....	....	....	18	2.49
Anisim	..	....	....	....	15	2.54
Delicious	14	2.50	2.90	13.8	33	2.81

*Probably not true to name.

VARIETAL POLLEN TUBE GROWTH

In Table III, the growth attained in all the different stigma cultures by each variety of pollen has been averaged. In the first columns of averages only those stigma cultures which were used in both tests are included. The last column represents the total average for all determinations.

It is apparent that, on the average, varieties of pollen differ markedly in respect to growth as measured by length of tubes under a given set of conditions. Delicious pollen seems to be particularly good, having produced in 33 different tests an average tube length of 2.81 mm. in 24 hours, as contrasted with the Winesap group which produced tubes measuring only 1.30 mm. to 1.89 mm., in about the same number of counts and during the same time.

More definite conclusions may not be drawn from these data, since, as shown in the table, the averages of the first and second tests are quite variable. Unlike the data in Table II, however, deviation occurs in both directions, indicating that the different varieties of pollen may have quite distinct temperature optima for tube growth. The marked increase in growth of Hibernal tubes in an average of 15 duplicate determinations, as well as the other plus

and minus deviations, may be explained, in part at least on this basis, though the variability of the material may have had its influence.

TABLE IV.

Average Percentage Pollen Germination as Affected by Each Variety of Stigma

Stigma Variety	Number of Varieties of Pollen used	Average Percentage Germination in Duplicate Observations First Test	Second Test	Percentage Variability in Germination, 2nd over 1st	Total Number of Observations	Average Percentage Germination
Check—No stigma added	11	41.7	54.6	23.6	28	52.4
Hibernal	9	57.1	72.9	20.3	27	63.8
Patten	9	57.8	76.1	24.0	28	65.8
Gilbert Winesap	..	....	....	....	15	54.0
King David	9	71.4	78.0	8.4	27	68.2
Delicious	9	63.8	69.8	8.6	26	67.0
Malinda	8	59.8	70.5	15.8	25	66.2
Tompkins King*	..	....	....	....	14	45.2
Jonathan	9	67.3	70.5	4.5	26	68.9
Rome Beauty	..	....	....	....	18	56.9
Stayman Winesap	..	....	....	...	14	60.8
University	11	62.2	72.6	14.3	28	66.6
Anisim	..	....	....	....	17	73.2
Oldenburg	11	63.2	75.8	16.6	29	66.8
Gano	9	66.3	75.4	12.0	26	72.1
Wealthy	11	62.3	66.5	6.3	28	65.8
Northwestern Greening	10	60.4	74.0	18.3	27	66.8
McIntosh	10	61.6	69.8	11.7	27	66.1

*Probably not true to name.

The rather striking grouping of the Winesaps as the poorest growers and the Delicious and Jonathan as among the best is, nevertheless, indicative of a correlation with observed pollination results, since the Winesaps are notoriously poor pollen parents and the Delicious and Jonathan usually give good sets of fruit. This fact suggests another reason, based on rate of tube growth, why some varieties may be better pollinizers than others. It is noted, also, by comparison with Table II. that the pollen tube growth rate and stigma stimulation of a given variety do not necessarily hold the same rank in the two tables. Delicious and Patten have very good pollen as measured by tube growth, but the stigmas are relatively weak in stimulating growth. Stayman Winesap, on the other hand, produces poor pollen tubes, but the stigma is relatively effective in stimulating growth, which is of interest, since this latter variety is known to be a fairly good pistil parent.

THE EFFECT OF THE STIGMA ON POLLEN GERMINATION

Table IV. presents the average germination of the different pollen as affected by a particular variety of stigma. In the first

column of averages, only those varieties of pollen which were used in both tests are included. The last column represents the average of all determinations, including the duplicates.

It may be seen from these data that the addition of any variety of stigma to the pollen culture has increased the average percentage of germination from 52.4 per cent in the check cultures, to approximately 65 per cent. In fact, if one disregards the averages of less than 20 determinations, it is clear that this increase has been quite consistent. The stigma, then, as an addition to the germination medium adds something which affects the rate of germination and initial growth of the pollen over a 24 hour period, but no one variety of stigma is more effective in this respect than any other variety.

TABLE V.

Average Percentage Pollen Germination of Various Varieties of Pollen Regardless of the Stigma Culture Used.

Pollen Variety	Number of Different Stiga Cultures Used	Average Percentage Germination of Duplicate Observations: First Test	Average Percentage Germination of Duplicate Observations: Second Test	Percentage Variability in Germination, 2nd over 1st	Total Number of Observations	Average percentage Germination
Gilbert Winesap	11	23.7	29.0	7.9	29	28.3
Stayman Winesap	18	46.5	31.6	32.0	37	36.9
Tompkins King*	..	.	..	....	18	41.7
Northwestern Greening	..	....		....	18	44.2
Hibernal	15	32.7	68.8	52.4	34	50.0
McIntosh	14	51.0	66.	22.7	33	52.4
Wealthy	14	48.3	84.1	42.5	33	65.4
Winesap	..	....	...	....	17	65.5
Patten	12	65.8	76.6	14.1	31	73.5
Oldenburg	12	69.2	71.4	3.1	30	76.4
Anisim	..	...	....	....	15	76.8
Rome Beauty	15	84.7	72.0	15.9	34	78.1
King David	10	69.6	90.4	23.0	30	79.9
Jonathan	15	90.5	87.9	2.8	37	83.0
Colorado Orange	..	....	....	....	15	83.7
Delicious	14	85.6	90.8	5.7	33	88.5
Gano	..	...	...	....	15	89.1

*Probably not true to name

It may follow, therefore, that the stigma has two quite distinct functions; it serves as the substratum upon which the initial processes of germination and growth take place, behaving merely as a good germination medium, and it affects the rate of pollen tube growth. Germination and rapidity of pollen tube growth are quite distinct, however, and are not necessarily corelated, since the data indicated that the stigma influences the growth. In view of the fact that little difference was noted in the percentage of germination, it is conceivable that the superiority of one kind of pollen

in effecting a good "set" of fruit, is due to the more rapid and greater growth of the pollen tubes.

It is noted from Table IV., also, that the differences between the first and second tests are not as large as was noted for tube length, indicating that the percentage of germination of all the varieties of pollen used was more independent of the environmental and inherent factors of pollen and stigma which influenced the growth.

Varietal Pollen Germination

Table V. presents the average germination of each variety of pollen irrespective of the variety of stigma culture in which germination took place. In the first columns of averages only those cultures which were used in both tests are included. The last column is the average of all tests, including the duplicates.

In the previous table the data showed that the average percentage of germination of all pollen does not vary appreciably with the kind of stigma used, but in Table V. it will be noted that the individual varieties of pollen show marked differences in this respect. Compare Delicious, which germinates 88.5 per cent of its pollen, and Gilbert Winesap and Stayman Winesap, which germinate only 28.5 per cent and 36.9 per cent respectively. While these percentages cannot be considered as being an index of the true sterility of the variety of pollen in view of the wide variations in percentage of germination found in the first and second tests, still the large number of counts in each should make them relative. If the highest average germination in the duplicate tests be taken as the optimum germination for each variety and the order rearranged, only minor changes would occur in the table. It is evident, then, that Delicious, Jonathan, and King David are superior to Gilbert Winesap and Stayman Winesap with respect to germination and the difference may be attributed quite largely to the difference in true sterility of the pollen.

A comparison of the data presented in Tables III and V suggests other peculiarities of varieties of pollen which may have a bearing on their ability to effect fertilization. On the average, in addition to growing slowly, Stayman Winesap and Gilbert Winesap pollen germinates only a small percentage of its pollen grains; Northwestern Greening, on the other hand, germinates poorly, but grows rapidly; Gano germinates well but grows poorly; and Delicious both germinates and grows rapidly.

Discussion and Summary

These data have not been presented in an effort to prove or disprove the question of the relation between pollen tube growth or pollen germination in relation to the stigma and sterility. The author is cognizant of some of the many criticisms which may justly be thrown on both the material and methods. The data appear to be of some value, however, in that they are suggestive of a possible correlation with results derived from controlled pollination studies, and throw some light on the physiology of apple pollen. They are given here more as suggestions to any who may be

interested in the question of pollen germiation, since they indicate some of the factors which must be taken into account by the experimenter, and also some conception of the variability to be expected in tests of this nature. The author believes that the van Tieghem cell may be much improved or modified to adapt it to more careful observations on the growth of pollen tubes, especially if the growth curve is to be studied. The temperature factor must be given consideration, but the sources of material and the germination medium, are equally important if comparable results are to be obtained. ,

The following general conclusions may be drawn from the data reported in this paper:

1. A culture medium containing 5 per cent sucrose plus one per cent gelatine proved very satisfactory for germination and growth of apple pollen.

2. On the average, pollen tube growth was stimulated by the addition of any variety of stigma to the germination medium.

3. McIntosh and Jonathan stigmas stimulated pollen tubes of all varieties to longer growth in 24 hours than did Hibernal and Patten.

4. Varieties of pollen differ in their ability to produce long tubes in a given period and under comparable conditions.

5. The presence of a stigma in the pollen culture caused better germination than when no stigma was present.

6. Considering all the varieties of pollen used, no one variety of stigma was superior to others in increasing the percentage of germination.

7. Varieties of pollen vary in their ability to germinate and the percentage of germination under optimum conditions may be a fair index of the percentage of effective pollen.

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The Study of Bearing Habit of Apple Varieties*

By W. B. Mack, *Agricultural College, Amherst, Mass.*

THE following is a preliminary report on an investigation begun last June, with the primary object of discovering, if possible, distinguishing differences in the manner in which different varieties of apple bear their crops of fruit. Further objects for study presented themselves early, those of associating quantity of crop with manner of bearing, and of relating differences of bearing habit with variations in external factors. At present the latter purposes are the ones most in view, since they appear most likely to be profitable in further investigation.

Methods of Study

The method of study has been to observe the present season's fruiting performance, to measure the previous season's growth,

*The Massachusetts Experiment Station furnished the cuts used with this address without expense to the society.

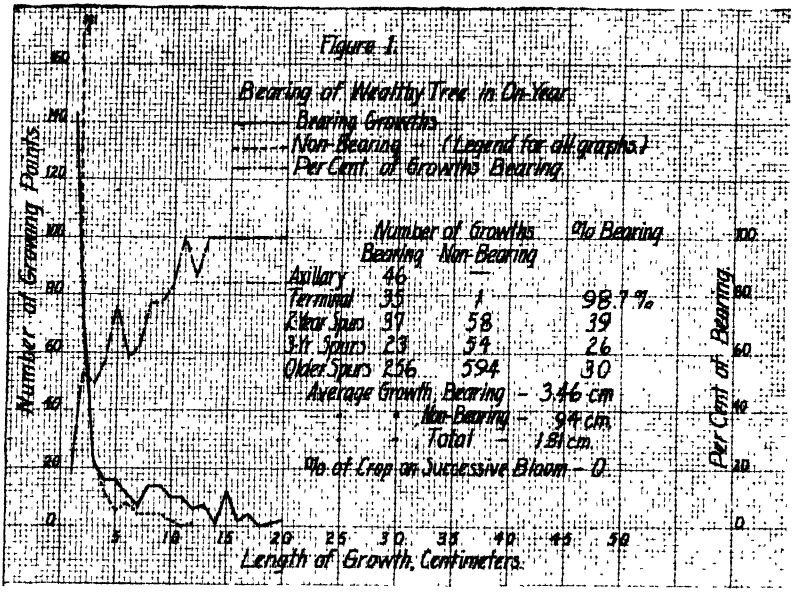
Figure 1.
Bearing of Wealthy Tree in On-Year
Bearing Growths
Non-Bearing (Legend for all graphs.)
Per Cent of Growths Bearing
Number of Growths
Bearing Non-Bearing
% Bearing
Axillary 46 —
Terminal 35 1 98.7%
2-Year Spurs 37 58 39
3-Yr Spurs 23 54 26
Older Spurs 256 594 30
Average Growth, Bearing – 3.46 cm
" " Non-Bearing – .94 cm
" " Total – 1.81 cm
% of Crop on Successive Bloom – 0
Number of Growing Points
Per Cent of Bearing
Length of Growth, Centimeters

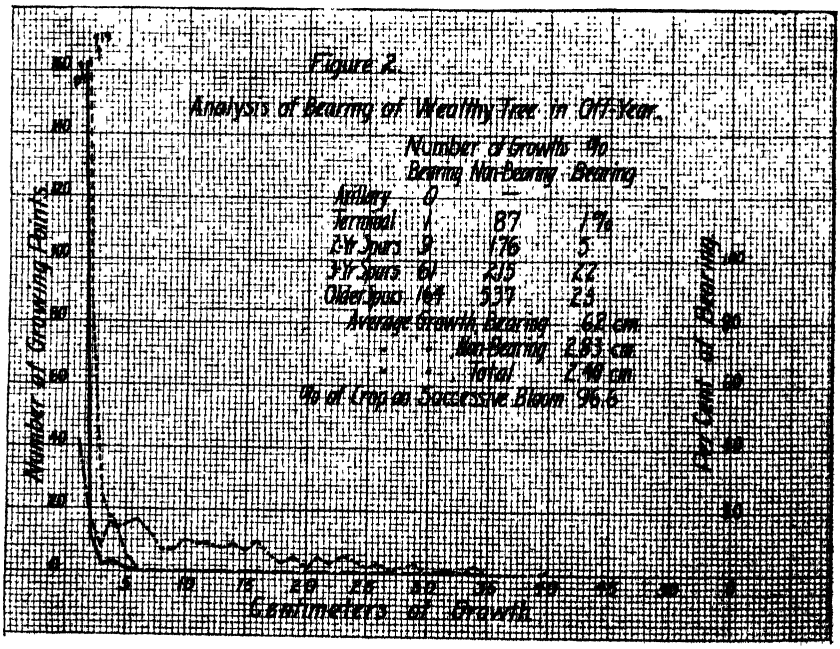
Figure 2.
Analysis of Bearing of Wealthy Tree in Off-Year
Number of Growths
Bearing Non-Bearing
%
Bearing
Axillary 0 —
Terminal 1 87 1%
2-Yr Spurs 9 176 5
3-Yr Spurs 61 215 22
Older Spurs 164 537 23
Average Growth, Bearing .62 cm
" " Non-Bearing 2.83 cm
" " Total 2.40 cm
% of Crop on Successive Bloom 96.6
Number of Growing Points
Per Cent of Bearing
Centimeters of Growth

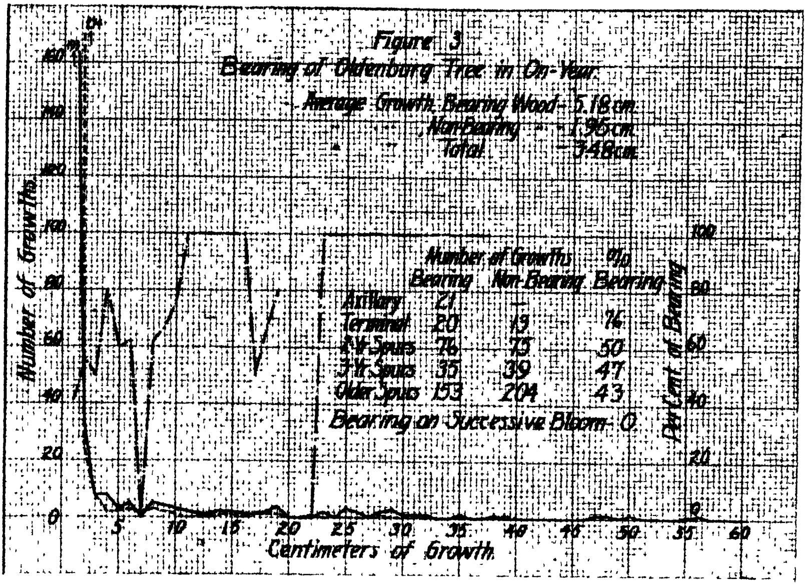
Figure 3
Bearing of Oldenburg Tree in On-Year
Average Growth Bearing Wood - 5.18 cm
Non-Bearing - 1.95 cm
Total - 3.48 cm
Number of Growths
Bearing
Non-Bearing
%
Bearing
Axillary 21
Terminal 20 13 74
2-Yr. Spurs 76 75 50
3-Yr. Spurs 35 39 47
Older Spurs 153 204 43
Bearing on Successive Bloom - 0
Number of Growths
Per Cent. of Bearing
Centimeters of Growth

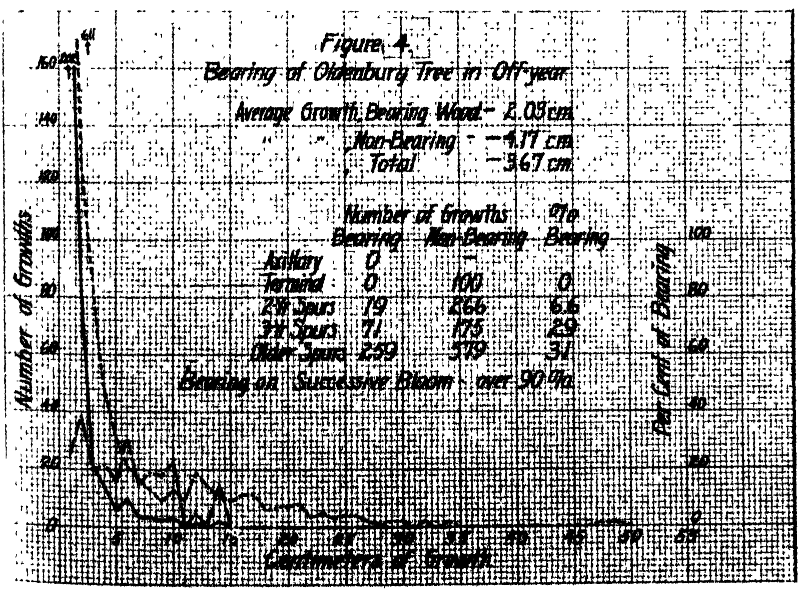
Figure 4.
Bearing of Oldenburg Tree in Off-year
Average Growth Bearing Wood - 2.03 cm
Non-Bearing - 4.17 cm
Total - 3.67 cm
Number of Growths
Bearing
Non-Bearing
%
Bearing
Axillary 0
Terminal 0 100 0
2-Yr Spurs 19 266 6.6
3-Yr Spurs 71 175 29
Older Spurs 259 579 31
Bearing on Successive Bloom - over 90 %
Number of Growths
Per Cent. of Bearing
Centimeters of Growth

and to note the position of every growing point. This was done with a representative group of branches if the tree were large, or with the entire tree if it were small. Growing points carrying fruit past the early summer drop were considered bearing, and all others non-bearing. No record was taken of bloom failing to set fruit, or setting fruit not carried past the June drop. Some observations of amount of bloom were made. Growths were classified as terminal if they originated from the terminal bud of wood on which the axilliary buds had produced spurs or shoots; otherwise as spurs on two-year, three-year, or four-year and older wood, according to the age of the wood on which they developed from axillary buds. Spur systems were grouped in the age class of the original spur from which they developed, and each growing point was counted as a spur. Lengths of growth were grouped into one centimeter classes. Axillary bearing, and combination of axillary and terminal as above defined, were each listed separately. No division of growths into spurs or shoots according to growth was made, though there is a little evidence that this might be done in the measurements, as indicated in the graphs shown latter. Where differences appeared other than those above classified, such as bearing from successive bloom, second growth late in the season, or mechanical injury, they were noted separately.

Extent of Work to Date.

These observations and measurements were made on about 40,000 growing points on 36 trees, of 10 varieties of common apple and one of crab. Trees of several varieties which were receiving different soil management and fertilizer applications, and some which were in heavy and light bearing under similar conditions, were studied. A few observations were made on trees receiving special pruning treatment, as thinning out by small cuts, or ringing, and a larger number on trees of different ages, as well as on distinctly biennial bearers. Some individual branch measurements were made, to determine the amount of branch-to-branch variation.

The deductions made at the present time are necessarily tentative because the number of trees observed under any one condition was unfortunately small, and because the summaries are from observations covering one year only. However, those are presented which are most characteristic throughout, or are present without exception in several cases.

Differences Between Varieties

As far as observed, the definable differences between varieties shown by this exact measurement, are only such that could be seen by more casual examination. For example, Wealthy and York Imperial spurs on bearing trees characteristically come into bearing younger than those of most other varieties studied. All varieties observed produced a part of their crop on axillary buds along terminal growths. Some varieties produce a greater part in this manner than others, but the difference cannot be stated

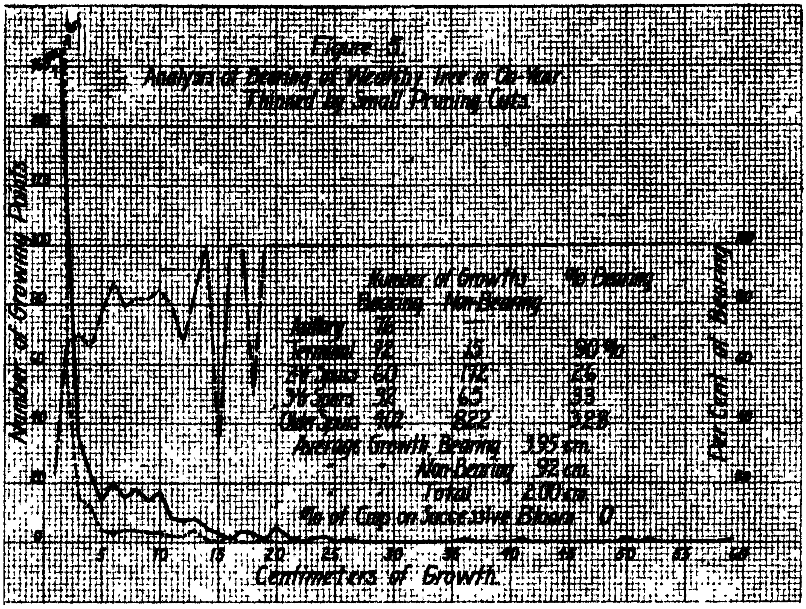
Figure 5.
Thinned by Small Pruning Cuts.
Number of Growths
Non-Bearing
% of Crop on Successive Elbows 0
Number of Growing Points
Per Cent of Bearing
Centimeters of Growth.

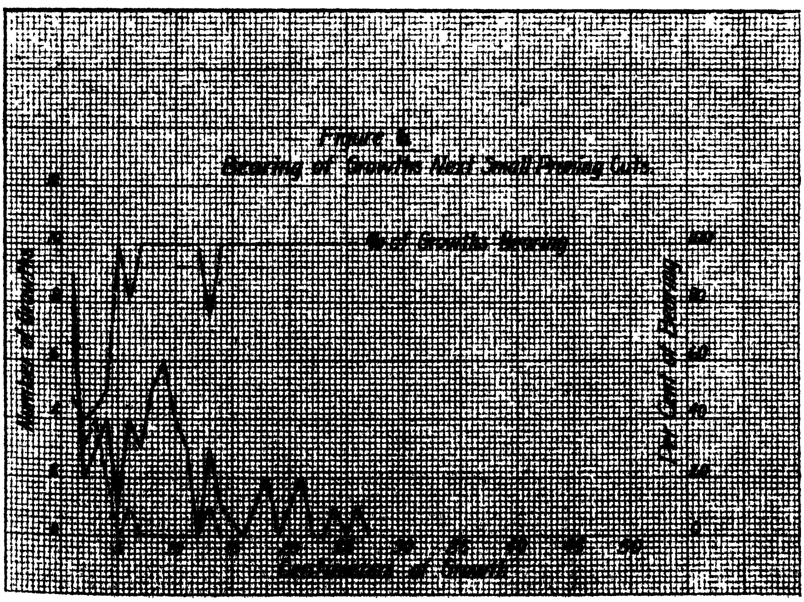
Figure 6.
Bearing of Growths Next Small Pruning Cuts.
% of Growths Bearing
Number of Growths
Per Cent of Bearing

definitely because of the great amount of variation within a variety. There is also some difference between the average growths of the spurs of different varieties, but this likewise varies between trees of the same variety with age and vigor, and with the on and off year.

The difficulty of defining differences between varieties on the basis of bearing habit, is shown also by the fact that the standard deviation of growth lengths of any tree is greater than the mean. The average growth was different from branch to branch on all trees on which branch records were taken. Evidently growing points of a tree do not form a homogeneous population.

Analysis of Biennial Bearing

Within varieties, however, differences in bearing habit seem to be quite distinct, according to certain conditions or factors. Biennially bearing trees of Wealthy, Baldwin, and Oldenburg, particularly mature trees distinctly of this type, habitually bear a large part of the crop of one year on terminal growths and on spurs on younger wood, and practically all of the succeeding crop on spurs on the older wood, especially those near the larger branches. In other words, one crop is carried on the smaller branches and growing points near the outside of the tree, and the next on the inner part of the tree, near the larger branches and the trunk.

The larger percentage of bloom is always associated with the blossoming of terminal growths and young spurs. Other factors being equal, the heavier crop will be so borne. For this reason this is termed the on-year in this discussion, and the opposite condition the off-year. Following are several characteristics of the on and off years, as thus defined: Bearing on axillary and terminal buds of terminal growths and on spurs on two-year wood, is very marked in the on-year, and in contrast little or none in the off-year. For example, two Wealthy trees in the on-year produced more than 20 and 25 per cent of their respective crops on axillary and terminal buds, 10 per cent on spurs on two-year wood, and six per cent, approximately, on spurs on three-year wood. A third Wealthy tree, adjacent to the second mentioned above, but alternating with it, bore none of its crop on axillary buds, one apple only on terminal growth, 3.9 per cent on spurs on two-year wood, and 26 per cent on spurs on three-year wood. Similarly an Oldenburg in the one-year bore 13.7 per cent of its crop on axillary and terminal buds, 25.5 per cent on spurs on two-year wood, and 10.4 per cent on spurs on three-year wood. A second Oldenburg in the off-year had no fruit on terminal growths, 5.4 per cent on two-year spurs, and 23.3 per cent on three-year spurs. In the on-year the percentage of spurs that bear increases with their growth. Practically all the long growths bear fruit. The reverse is true in the off-year, when very few of the long spurs and terminal growths bear. (Figures 1 and 2). The average growth made during the previous year on all growing points was less on trees in the on-year than those in the off-year. In

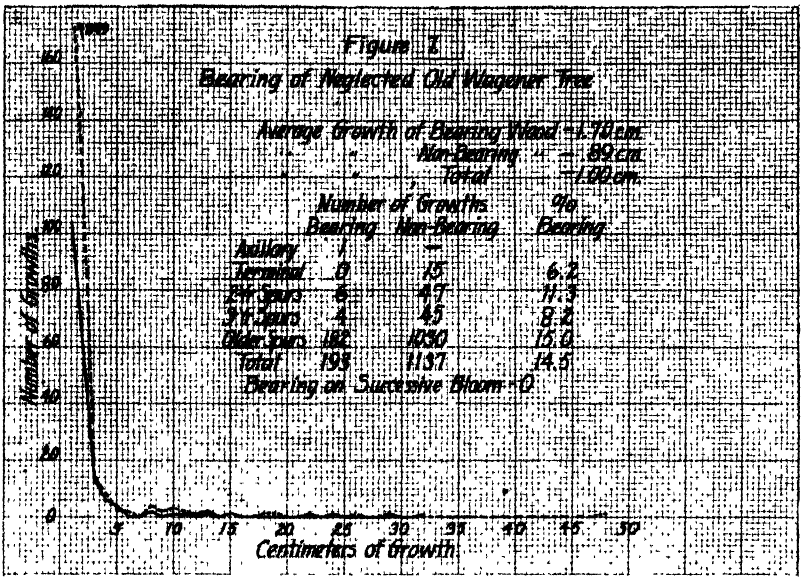
Figure 7
Bearing of Neglected Old Wagener Tree
Average Growth of Bearing Wood = 1.78 cm.
" " Non-Bearing " = .89 cm.
" " Total = 1.00 cm.
Number of Growths %
Bearing Non-Bearing Bearing
Axillary 1 —
Terminal 0 15 6.2
2 Yr. Spurs 6 47 11.3
3 Yr. Spurs 4 45 8.2
Older Spurs 182 1030 15.0
Total 193 1137 14.5
Bearing on Successive Bloom = 0
Number of Growths
Centimeters of Growth
0 5 10 15 20 25 30 35 40 45 50

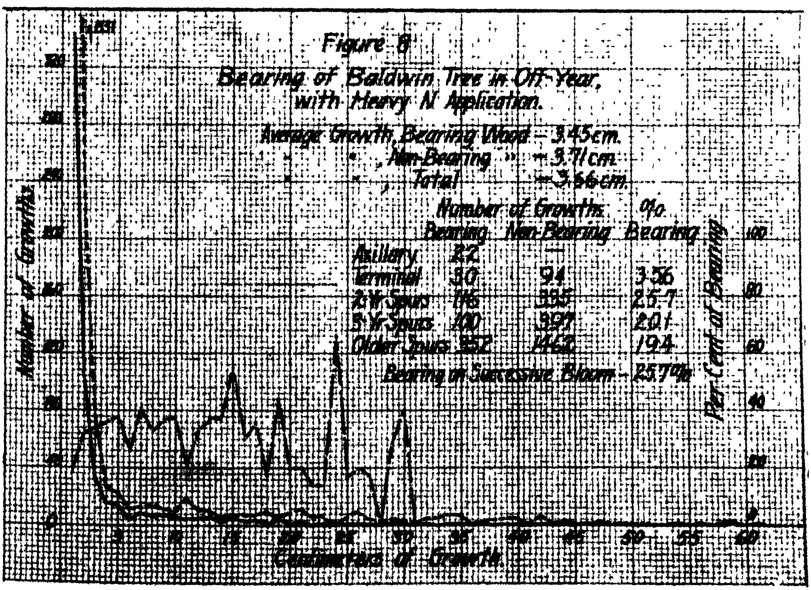
Figure 8
Bearing of Baldwin Tree in Off-Year,
with Heavy N Application.
Average Growth, Bearing Wood = 3.45 cm.
" , Non-Bearing " = 3.71 cm.
" , Total = 3.66 cm.
Number of Growths %
Bearing Non-Bearing Bearing
Axillary 22 —
Terminal 30 94 3.56
2 Yr. Spurs 116 335 25.7
3 Yr. Spurs 100 397 20.1
Older Spurs 352 1462 19.4
Bearing in Successive Bloom = 25.7%
Number of Growths
Per Cent of Bearing
Centimeters of Growth
100 80 60 40 20 0
50 55 60

other words, the tendency of biennially bearing trees is to bear the larger crop and make the longer average growth in the same season, and to develop the greater number of blossom buds the next year. This condition existed on all biennially bearing trees studied. (Figures 1, 2, 3 and 4). There was no maximum growth beyond which bearing decreased in the on-year, since nearly all the longer growths bore one or more fruits, and practically none failed to bloom. Blossoming and bearing on watersprouts was not uncommon in the on-year.

In the off-year position seems to be important. Terminal growths have a very small or no percentage of bearing and the two-year spurs very little. The percentage of bearing increases with the age of the spurs. However, the average length of bearing growths is less than that of non-bearing in the off-year, while in the on-year the reverse is true.

Bearing on spurs which blossomed the previous year is very rare in the on-year, but is quite common during the off-year. The Wealthy trees in figures 1 and 5 had no bearing from successive bloom, while the one in figure 2, in the off-year, typical of eight other trees in the same row, had more than 95 per cent of its crop on spurs which had blossomed the previous year. The same contrast was shown by the Oldenburg trees in figures 3 and 4. A row of McIntosh trees next the Wealthys mentioned above produced about 80 per cent of their crop this year on successively blooming spurs. These trees blossomed on but 30 per cent of their spurs and practically none of the terminal growths this year, and last year on 80 per cent of spurs and more than 50 per cent of terminal growths.

In biennial young trees the bearing habit in the on-year is similar to that of mature trees, except that the average growth is longer under similar external conditions. During the off-year, much of the bearing is on very long growths, especially those which make a second growth late in the season.

Effects of Pruning on Bearing Habit

So far as observed, pruning had no measured effect on bearing habit. Growths stimulated by adjacent pruning cuts, whether large or small, behaved as those of similar length on the rest of the tree. If the trees were in the on-year, they blossomed and bore fruit in increasing percentage with increasing growth; if the trees were in the off-year, they failed to fruit at all. Figure 5 shows the bearing habit of a Wealthy tree thinned out by small pruning cuts, and figure 6 shows the bearing of spurs next the cuts. Both indicate that these small cuts failed to throw adjacent spurs out of bearing by increasing their growth.

Effects of Nitrogen on Bearing Habit

There seems to be some effect of nitrogen on bearing habit. Apparently there is more terminal bearing and also more bearing on young spurs on trees receiving nitrogen applications than on those receiving none. As an example of the latter, an old Wagener

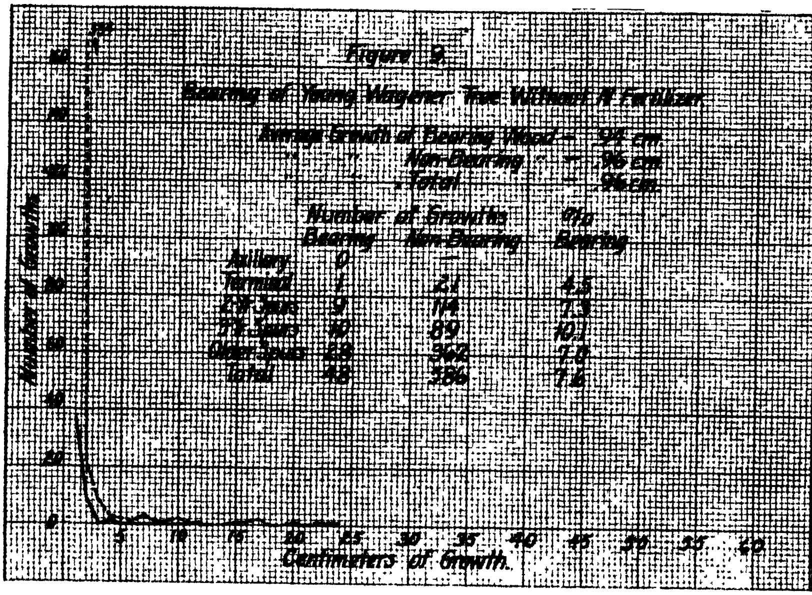
Figure 9.
Bearing of Young Wagener Tree Without N Fertilizer
Average Growth of Bearing Wood — .94 cm
Non-Bearing — .96 cm
Total — .96 cm
Number of Growths %
Bearing Non-Bearing Bearing
Axillary 0 —
Terminal 1 21 4.5
2 Yr Spurs 9 114 7.3
3 Yr Spurs 10 89 10.1
Older Spurs 28 362 7.0
Total 48 586 7.6
Number of Growths
Centimeters of Growth
5 10 15 20 25 30 35 40 45 50 55 60

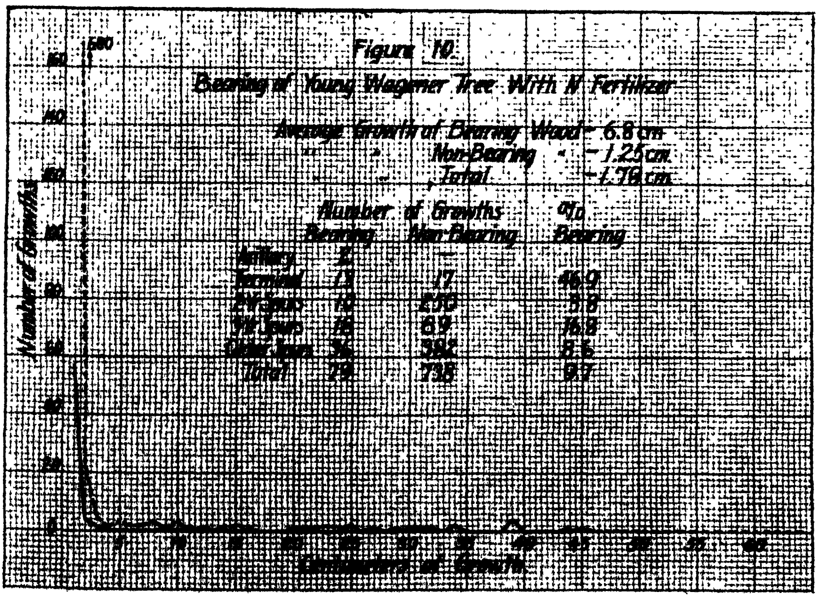
Figure 10.
Bearing of Young Wagener Tree With N Fertilizer
Average Growth of Bearing Wood — 6.8 cm
Non-Bearing — 1.25 cm
Total — 1.79 cm
Number of Growths %
Bearing Non-Bearing Bearing
Axillary 2 —
Terminal 15 17 46.9
2 Yr Spurs 10 250 3.8
3 Yr Spurs 16 69 16.8
Older Spurs 36 382 8.6
Total 79 738 9.7
Number of Growths
Centimeters of Growth

tree in a neglected orchard, bearing a good crop and evidently in the on-year, showed no terminal bearing, and had but one apple on an axillary bud, six on two-year spurs, and four on three-year spurs, in a total of 193 bearing points. (Figure 7). In contrast to this a Baldwin tree which has received annual applications of 15 pounds of sodium nitrate for the last two seasons bore eight per cent of its crop on terminal growths, and 19 per cent on two-year spurs, which was more than on any other mature Baldwin trees studied. (Figure 8). Young trees of McIntosh, Baldwin, and Wagener which received nitrogen applications bore more fruit on very long terminal growths, especially those making second growth, than those which received none. (Figures 9 and 10). Of Wagener trees ringed in 1918, those receiving nitrogen applications had considerabe bearing on successively blooming spurs, while those receiving none bore very little fruit on such spurs. Three of these trees receiving nitrogen had 83 per cent, 34.7 per cent, and 32.7 per cent of their respective crops on successively blooming spurs; three receiving no nitrogen had a total of 4 apples on such spurs, in a total of 97.

Nitrogen evidently tended to promote bearing on new wood and young spurs and favored bearing on successively blooming spurs. That the latter type of bearing may be important in securing annual bearing is shown by the fact that the off-year Wealthy trees previously mentioned had good crops, in some cases enough to require propping. The Oldenburg tree in figure 4 and the Baldwin in figure 8 also had heavy crops. Both were in the off-year as indicated by bearing habit and by previous performances.

Summary

The following facts were evident in this year's bearing:

1. On-year bearing was marked by much bearing on all parts of the tree, particularly on the parts that made the more vigorous growth during the previous season.

2. Off-year bearing on mature trees was carried largely on sucessively blooming spurs on the older wood, and near the larger branches.

3. Young trees showing a biennial tendency bore a large part of their off-year crop on long growths and late second growths.

4. Biennial trees in the off-year had made greater average growth during the previous season than those in the on-year.

5. Nitrogen favored bearing on terminal growths and young spurs, and on successively blooming spurs in the off-year.

6. Pruning had no effect on bearing habit.

These facts may be applied as follows:

1. Uniformity of behavior of all spurs on a tree in certain respects indicates that the tree and not the individual spur determines the performance of the spur.

2. If fruit bud differentiation is a consequent of the presence of sufficient storage materials, particularly carbohydrates, in pro-

portion to nitrates, this condition prevails throughout the growing season in the off-year. The proportion of carbohydrates increases as the growing season advances, since the longer growths, or in other words, those forming their terminal buds latest, form the highest percentage of blossom buds.

3. The smaller branches are exhausted of reserve materials in the early part of the on-year, and continue to be low in carbohydrate-nitrogen ratio until after most growth has stopped. This is indicated by the fact that only very long growths, or those making second growth, form blossom buds for the off-year.

4. The larger branches and possibly the trunks of mature trees retain sufficient storage materials after the setting of the on-year crop to differentiate blossom buds on the short spurs near these larger branches. This is especially true on trees well supplied with nitrogen.

5. Early formation of terminal buds, or slow growth, is associated, with blossom bud formation, as indicated by shorter average growth during the season when most blossom buds are formed.

Secondary Flowering of the Apple

By C. G. Vinson, *Experiment Station, Wooster Ohio.*

KILLING temperature for fruit buds occurred in Pennsylvania in the spring of 1921 on March 27, April 11 and April 18. Opening buds in the southern part of the state were killed by the first freeze, especially Smokehouse and Stayman Winesap. On May 7, a visit was made to the fruit section of Adams County around Bendersville In an orchard near Arendtsville a young Smokehouse tree, about eight years old, was observed which was covered with blossoms. The tree naturally attracted attention for Smokehouse bloom had been over for at least three weeks. On examining the blossoms and spurs closely I was much astonished to find that these clusters were borne on shoots arising from the cluster bases which had lost their flowers due to freezing. That same day the same condition was found on York Stripe in the orchards of the American Fruit Growers, Inc., at Flora Dale. On May 9, a visit was made to the Experiment Station orchard at State College and there the same thing was taking place abundantly on Smokehouse and to a slight extent on Summer Rambo. Observations showed that many of these flowers set fruit, and that the fruit was carried to maturity. Being engaged in Extension work at that time, extensive observations, however, in any one place were not possible.

Work was taken up at the Ohio Agricultural Experiment Station in the spring of 1922 and on May 22 a tree of Utter was found in the Station orchard bearing a large number of flowers in the same manner as those found on Smokehouse in 1921.

The Utter tree stands with others in a corner of the orchard in a sort of pocket and nearly all the first flowers on the lower part of the tree were killed by frost. The manner of abscission of the latter clusters seemed a bit different. Instead of leaving a mass of cork tissue at the scar of the absciss layer apparently formed farther down and left a very smooth scar. This may have been due to the killing of those tissues by cold, and then the absciss layer formed below the killed portion.

This tree has been making 10 to 15 inches of terminal growth. It seems to have a strong tendency to bear fruit on the terminals, even on the strongest ones. The trunk shows winter injury from the winter of 1921 and 1922 and also injury of a much earlier date, probably from the winter of 1917-18.

The record shows that Utter was in full bloom April 28. Several fruits which had set from the first bloom were on the tree and these averaged about eight-tenths of a centimeter in diameter. On the 23rd of May 370 flower clusters, in full bloom, were counted on this tree. One-hundred of these clusters had a total of 198 flowers, or an average of about two flowers per cluster. The highest number found in a cluster at this time was five and many clusters consisted of a single flower. Toward the top a greater number of fruits had set from the first flowers, and here there were far less secondary flowers. But in some cases three and four fruits had set from the primary cluster and yet a secondary cluster appeared on the same spur.

On May 27, 30 flower clusters in bloom were counted and on June 6, 40 more were counted. It was very noticeable that clusters open on June 6 were borne on new growth which was much longer than that upon which the clusters opening May 22 were borne. Most of the former were borne on the east side of the tree, and on those branches arising above the worst injured portion of the trunk. The shoot growth, bearing flowers opening June 6, averaged 5.05 cm. in length, the longest being 13 cm. and the shortest 2 cm. These shoots had an average of 6.35 leaves.

Those clusters opening June 6 averaged the same number of flowers per cluster, two, as those open May 23, but one cluster was found with six flowers.

On June 7, 31 more clusters, in bloom, were counted. Many of these blossoms especially the terminal ones were almost, if not quite, sessile. One cluster composed of five flowers was found open on Utter June 17, and the last one found open was on June 20. The latter cluster had six flowers, the shoot was 4 cm. long and had eight leaves of full size upon it. The total number of secondary blossom clusters counted on Utter was 473. These were all marked by tags, appropriately marked to indicate the date as the clusters were counted.

The fruit on Utter was harvested September 9. A total of 1053 apples were picked, 367 of which were from flowers of secondary clusters, the remainder, 686, were produced, of course, from primary clusters. From these figures it is seen that 34.85 per cent of the fruits on the Utter in the season of 1922 came from secondary flower clusters. As noted earlier this tree stands in a sort of

pocket and in the spring it was noticed that more primary clusters were killed on the lower part of the tree and that there were more secondary clusters near the ground. The fruit harvested bore out this observation. The number of fruits from primary clusters harvested from bottom of tree up to 9 feet was 390. The number of fruits from primary clusters harvested above 9 feet was 296. The number of fruits from secondary clusters harvested from bottom of tree up to 9 feet was 314. The number of fruits from secondary clusters harvested from above 9 feet was 53. Thus it is seen that over 85 per cent of the secondary fruits were borne below the nine foot level of the tree.

The difference in size between fruits from primary clusters and those from secondary was not great. Of the fruits from primary clusters 97.95 per cent was 2½ inches or above in diameter, and 93.82 per cent of the fruit from the secondary clusters was 2½ inches and over in diameter. Most of the fruits from the secondary clusters were normal in shape and appearance, but several were found that were abnormally oblate and had a very shallow cavity, or no depression around the stem at all, which is by no means typical of the variety. Upon sectioning such fruits it was invariably found that seeds were absent from one or two loculi. Cleared sections from these fruits also show an entirely different arrangement of the primary vascular bundles from those of the fruits from primary clusters, or normal fruits from secondary clusters.

Flowers of secondary clusters were found open on Yellow Transparent and Oldenburg on May 24. What appeared to be cauliflory was found on Oldenburg at this date. Shoots coming from cauline buds bore flowers. One such flower set fruit and the fruit was carried to maturity. This particular fruit was almost sessile and no leaves were borne in connection with it.

In the case of Yellow Transparent it seemed that secondary clusters were borne on the weaker spurs. In a few cases the secondary clusters consisted of only one flower, and here, at times, the secondary cluster-base arose as an ordinary individual fruit pedicel, only the pedicel of the secondary flower was usually quite long and bracteoles were inserted upon it.

On June 6, a spur was found on Oldenburg which had blossomed, but the cluster had aborted. A bud from the cluster base had produced a shoot, and two centimeters from the base this shoot had divided. One division grew out 8.9 centimeters and then produced two flowers on its terminal. The other twin shoot was 10 centimeters long at this time. The terminal bud formed on the latter shoot August 19, at which time it was 16 centimeters long.

A similar shoot was found on Utter June 7, but in this case both forks produced three flowers each on their terminals.

It is obvious that the bearing of secondary blossom clusters is not confined to spurs where frost had killed the first cluster or where the first cluster had been shed from any cause. Some secondary flower clusters were found on Oldenburg and also Yellow Transparent where the primary cluster-base was bearing one and

sometimes two well developed fruits which averaged about 2.5 cm. in diameter on June 8.

A secondary blossom cluster consisting of one flower was found open on Oldenburg on June 13.

The first picking of Yellow Transparent was made July 7. At this first picking it was noticed that it was hard to detach the pedicel from the cluster-base. On three large Yellow Transparent trees, 67 spurs were found carrying fruits from secondary clusters to maturity, and 993 other spurs were found where the secondary clusters had aborted. On the two large Oldenburg trees, 404 spurs were found carrying fruits from secondary clusters to maturity, and 50 spurs were found where the secondary clusters had aborted. In the case of Yellow Transparent certain areas in the top seemed to bear secondary clusters more abundantly, and in the case of Oldenburg certain branches bore secondary blossom clusters more abundantly than other branches.

On July 10, a flower was found on one of the Yellow Transparent trees. This flower had lost its petals and must have been in full bloom about July 5. The pedicel of the flower was unusually long, 3.4 cm., and a stipular growth was upon the pedicel. This flower came from a bud immediately below the primary cluster base, that is, from a bud which was formed immediately below the terminal one. Another such flower borne in a similar manner was found this same day on the same tree. The latter flower still had its petals. No leaves were borne with the above flowers.

The first part of August, on one of the Yellow Transparent trees, it was noticed that many leaf buds below the base of primary cluster-bases were breaking. This tree was watched very closely to see if any of the breaking buds might contain flower parts. On August 10, a cluster of two flowers from a bud below the cluster-base, which bore fruit in 1922, was found. One of these flowers had a very long pedicel, 4.5 cm. On August 12, another flower was found, one stamen of which showed a condition of petalody. By the middle of August, buds at the base of the cluster bases on other Yellow Transparent trees were breaking, and a few flower clusters were produced on each tree. In all about 20 flower clusters were found on Yellow Transparent during August. One cluster consisted of four flowers. One flower was found with a double whorl of petals and a corresponding reduction in the number of stamens. The anthers of these flowers bore a very small quantity of pollen. Some of the pollen was placed on 6 per cent sucrose agar, but only a small percentage of the grains produced pollen tubes. From these 20 clusters, two fruits set and were carried until picked on October 14. The blossom from which the larger of these two fruits set was open August 25. When picked the larger fruit measured .9 cm. x 2 cm. It had four carpels, but none of the carpels contained seeds.

No new leaves were produced along with any of the above flowers. These buds were, therefore, apparently not compound. But on September 1, a flower was found on an Oldenburg tree and this flower was accompanied by two small leaves. This was the

first flower found from a compound bud since June 20. This flower was produced from a bud below the base of a cluster base which had borne fruit.

On August 9 a flower was found, on Yellow Transparent, arising from a lateral bud on the primary cluster base, showing distinctly that the primordia had been laid down since growth began in the spring. Other clusters were found arising from a similar position.

During the period of blossoming of Yellow Transparent in August, it was noticed that where small branches or twigs were broken when the fruit was picked in July, buds below the wound or break were invariably forced into growth during August. This seemed to indicate that the breaking of buds and flowering of Yellow Transparent in August might be due to a wound stimulus. Accordingly, it was decided to wound some of the primary cluster bases to see if breaking of buds could be induced. On August 25, some cluster bases of Yellow Transparent and Oldenburg were cut across. Thursday September 14, 20 days after cutting back, it was noticed that buds were pushing immediately below the primary cluster base of those which had been wounded. One spur was found where both buds immediately below the cluster base were pushing and one of these consisted of a single flower in the pre-pink stage. This was considered as fair evidence that the stimulus that caused the wholesale breaking of Yellow Transparent buds in August was a traumatic one. This wound stimulus was possibly given in the first picking where the fruits were so hard to remove as mentioned previously.

On September 18, flowers were found on young Jonathan trees in an orchard near the Experiment Station. These trees had been defoliated early and were making a second growth. On one tree two blossom clusters were found, each of which came from an axillary bud on growth made in 1922. These two clusters showed some of the characters of secondary clusters in that the base of each was unduly elongated. One cluster base was 4 cm. long, bore four flowers and had eight leaves. The other cluster base was 2.5 cm. long, bore nine flowers and had six leaves.

Proliferation

Mention has already been made of finding terminal flowers of the secondary clusters on Utter quite sessile. Consequently, petioles of leaves on the secondary cluster base were very close to the receptacle.

On June 7 a peculiar looking fruit was found on Utter. Nothing had ever been noted in the literature concerning such a specimen. This fruit had a normal calyx and also three leaf-like structures inserted upon the torus. Another fruit was then found with a whorl of three leaves at the cavity, the bases of the petioles were united around the stem of the fruit and were becoming fleshy. Later a small fruit was found on Oldenburg showing the beginning of the bases of petioles to fleshen when in contact with the fruit. Two other specimens were found on Oldenburg showing a greater degree of enlargement of the petioles of leaves and

their envelopment of the fruit. The petioles of four leaves made up the proliferated portion of one fruit, and the petioles of five leaves made up the proliferated portion of the other. One of these fruits had a large leaf-like structure inserted on the torus. This structure was certainly not derived from a leaf, but from a sepal. The above mentioned fruits were surely developed from the sessile terminal flowers noted earlier.

June 26 a small fruit was formed on Utter with three sessile leaf-like structures at the basin. This appeared to be another fruit similar to those found on Oldenburg where the petioles had become united to the torus. But it is now believed that the leaf-like structures at the basin were merely enlarged supernumerary calyx lobes. The reason for this opinion is based partly upon the appearance of the structures and also upon examination of cleared sections of this fruit as compared with sections of a fruit which had an enlarged calyx lobe. The distribution of the primary vascular bundles in the two specimens is very similar. It is interesting to note that the distribution of the primary vascular bundles of the oblate secondary fruits of Utter resemble those of the two specimens mentioned above also. These sections will receive further study.

Such specimens of fruits are striking, but in themselves are only of secondary interest. One of the important things to note is the change in character of growth of the petiole when in close enough contact with the fruit to become grafted upon it.

Discussion

Since so many flowers were found on Yellow Transparent without accompanying leaves and with so few flowers in a cluster, a question arises as to food material and fruit-bud formation. Certainly the single flowers were not produced by an abundance of food material such as is responsible for the cluster of three to seven flowers in springtime. An abundance of food material may be necessary for the formation of strong fruit-buds, but it would seem that other factors aside from supply enter in, notably the kind of substance present.

There arises a further question as to whether flower-buds were formed immediately below cluster-bases which did not carry fruit, or those which carried fruit until entirely mature and thus easily removed. That is to say, were the flowers, which came from buds immediately below the primary cluster-base, normally formed and then called out prematurely by a traumatic stimulus, or did the early removal of fruit also have something to do with the laying down of the primordia of these flowers, the same as killing of the first flowers by frost, in the case of Smokehouse, seemed to make for secondary flowering?

One of the first questions arising in connection with secondary flowering in the spring is in regard to the time of laying down of the primordia of such clusters. It would seem entirely premature to conclude that promordia of blossom clusters on secondary shoots, opening in the spring, are laid down after growth begins in the spring, even though the bit of evidence presented in

the case of Jonathan does not preclude that very possibility. In addition the following question is raised. Is it possible that under certain conditions of metabolism, in the apple, long embryo shoots may have floral parts laid down upon their terminals? If so, what is the nature of this metabolism which produces such results?

Some shoots were found on Utter and Oldenburg where a third flower cluster was produced. One spur noted on Utter blossomed, but the entire cluster fell. A bud from the cluster base pushed and the resulting shoot bore a flower cluster May 23, and then farther out another flower cluster was borne about June 6. One fruit set on the second flower cluster.

Whether the secondary flowering noted in springtime is virtually a case of successive laying down of primordia the same season and hence a case of repeated flowering, is yet a moot question. The observations made so far indicate that the majority of shoots with secondary flower clusters are produced from cluster-bases where the first flower cluster has been shed. If this is a case of repeated flowering, certainly it is nothing unusual in the plant kingdom. It is a well known fact that a bean plant (Phaseolus vulgaris) may be kept in constant bloom throughout the growing season by keeping the green pods removed. A weigelia shrub was noted in 1922 which, after full bloom, always had a few flowers throughout the remainder of the growing season. Secondary flower clusters of the type produced on Smokehouse in 1921 have so far been noted on 17 different varieties, so the phenomenon is believed to be of widespread occurence.

Flowers on the terminals of elongated shoots, as pointed out previously, cannot be considered as evidence that the primordia are laid down the same season where such flowers open in the spring. Elongated cluster bases are not at all unusual, for the Summer Pearmain in the season of 1922 had long primary cluster bases. One seedling apple tree at the Ohio Experiment Station was found which had exceptionally long primary bases. Many of these cluster bases were 4cm. long. The quince bears its flowers on the terminals of new growth, and the primordia of these flowers are laid down the growing season previous to blossoming; so it would seem that such primordia could be laid down on the terminals of the longer growing apple shoots also.

As to whether secondary flowering in springtime has been common in the past is a question. It first came to the writer's attention in 1921, but the secondary cluster bases have been found on wood produced in 1920. So far, any reference in the literature to this condition has not been found. Peculiar types of inflorescences have also been noted recently in the potato, E. S. R. Volume 47, Number 4, Pg. 327 and in Agropyron cristatum, E. S. R. Volume 47, Number 4, Pg. 334.

A case of late flowering was also found on Early Richmond cherry.

Further Observations on the Fruiting Habit of the Concord Grape

By N. L. PARTRIDGE, *Agricultural College, East Lansing, Michigan*

STUDIES on the fruiting habit of the Concord grape reported last year were continued this past summer. Last year's report was based on work in a single vineyard at Grand Rapids; this year's results include two additional vineyards, located near Paw Paw, Michigan. One of these, the Buskirk vineyard, is located on a medium loam soil; the other, the Waller vineyard, on a rather light sand. The Grand Rapids vineyard is located on a heavy loam. These soil characteristics seem to influence the productivity of these vineyards, the average crop increasing as the soil becomes heavier, so that the crop of the heavy loam vineyard is the heaviest, that of the medium loam vineyard intermediate, and that of the light sandy vineyard the smallest. The vigor of the vines, as measured by the weight of prunings, was greatest in the Munson block, where 3.9 pounds of prunings was the average per vine preceding the crop of 1922, and 3.4 pounds preceding the crop of 1921. The weight of prunings in the Buskirk and Waller vineyards preceding the crop of 1922 was almost the same, being 2.1 and 2.2 pounds respectively.

In strong contrast to the crop of 1921, the past season has been one of heavy production, even in the Grand Rapids vineyard which was not materially injured by the freeze last year. The Paw Paw vineyards lost a large part of their crop last year; consequently, the crop this season is even larger in proportion to last year's.

In 1921, the data obtained from the Munson vineyard led to the belief that the 9-bud canes produced a greater average yield per node than did canes of either a greater or lesser length (1). This year with results from three vineyards available for comparison, it appears that there are differences between vineyards; that the best cane length in one is not necessarily the best in another; and further, that the best cane length in a given vineyard may vary from year to year following changes in vegetative conditions. The comparative figures are given in the following table:

[1]A note on the fruiting habit of the Concord grape, N. L. Partridge, Amer. Soc. Hort. Sci., 1921, pp. 193-196.

AVERAGE YIELD IN OUNCES OF ALL BUDS ON FRUITING CANES OF DIFFERENT LENGTHS.

Number of buds on cane	Heavy Loam 1921	Heavy Loam 1922	Medium Loam 1922	Light Sand 1922
1	2.6 (156)	6.8 (19)	3.4 (13)	4.0 (2)
2	1.9 (144)	4.0 (68)	3.2 (34)	0.9 (6)
3	1.5 (14)	4.3 (29)	3.5 (9)	1.8 (3)
4	2.3 (40)	5.1 (33)	4.8 (8)	2.6 (14)
5	2.7 (79)	6.8 (25)	5.4 (15)	4.0 (18)
6	2.3 (70)	6.4 (45)	5.5 (29)	2.9 (32)
7	3.1 (69)	5.7 (64)	5.8 (40)	3.6 (29)
8	2.8 (49)	5.8 (63)	7.0 (47)	5.2 (42)
9	3.8 (23)	6.0 (56)	7.8 (53)	5.0 (37)
10	2.9 (21)	7.0 (39)	6.3 (31)	4.6 (43)
11	2.2 (14)	6.6 (19)	6.2 (36)	4.8 (37)
12	3.2 (7)	6.9 (10)	6.7 (24)	4.5 (27)
13	5.9 (1)	7.7 (4)	6.0 (9)	4.3 (19)
14	3.7 (3)	8.2 (1)	3.9 (6)	5.4 (8)
15	......	10.1 (1)	......	3.6 (8)

(Numbers in parentheses indicate number of canes from which average is calculated.)

The curves produced by plotting the above data are very irregular, doubtless because of the rather limited number of canes studied in each of the vineyards, particularly those carrying the greater number of buds. It is unlikely, however, that it will be possible to increase the number of canes studied in any one year to such a point that a smooth curve can be expected for the longer cane lengths. However, the table shows that there are differences and similarities in the behavior of these vineyards that have a real value in pruning the Concord grape. In the first place, the optimum cane length indicated in the sandy vineyard is 8 buds; in the medium loam vineyard and in the heavy loam vineyard in 1921, when it was less vigorous, it is 9 buds; and in the heavy loam vineyard in 1922 no optimum is indicated at all, for the longer the canes the higher the average yield per node becomes. The less fruitful and less vigorous vineyards seem to show a curve of the optimum type; the most vigorous vineyard in 1922 does not show an optimum at all. In this last vineyard there is a point where the curve representing the average yield per node rises and then falls, being higher where the canes were pruned to 5 and 6 node lengths, however, the ultimate rise of the curve is considerably higher.

In practice, the location of such optima would be quite difficult. However, the knowledge that such optima do exist, and their approximate location, should be of value in designing pruning and training practices to suit local conditions. The fact that in all of these curves which show optima, the fall in average yield per node is much less rapid with increased cane length beyond the optima than with decreased cane length, is also interesting. The relative length of the most fruitful canes seems to vary directly with the average fruitfulness of the vineyard and also directly with the size of the crop that may be expected in a single vineyard. The vines may well be pruned with this condition in mind.

Observations were made this year as to the origin of certain of the different canes in these three vineyards, whether the bud from which the cane grew in 1921 was located on a cane, a spur, or grew from an adventitious bud on trunk or arm. In this last case, it is listed below as a watersprout. Some canes are branched, and some of these branches were reserved for fruiting, in which case they are listed as secondaries in the table below.

RELATION OF YIELD OF CANES TO THEIR ORIGIN.

Fruiting Cane grew from:	Average Yield per Node in Ounces, Crop of 1922. Heavy Loam	Medium Loam	Light Sand
Bud on cane of 1920	6.2 (273)	7.0 (194)	5.7 (172)
Bud on spur of 1920	5.9 (131)	5.7 (67)	4.8 (72)
Adventitious bud in 1921 (watersprout)	6.1 (66)	5.6 (90)	4.5 (84)
Bud on cane of 1921 (secondary)	7.1 (49)	8.4 (71)	6.0 (32)

(Numbers in parentheses indicate number of canes from which average is calculated.)

In each of these three vineyards the highest average production per node is found on the secondary branches of the canes grown in 1921. However, since these secondary buds sometimes are subject to more serious injury from spring frosts and freezes than are the buds on the parent canes, different results might be expected in another season, or under different local conditions. Another point of interest is the yield from the watersprouts. Though the average production per node is lowest for this type of cane in two of the three vineyards, these canes do not justify the reputation of unfruitfulness that they bear with many horticulturists.

Attention was also directed this past season to the relation between fruitfulness of canes and their diameter. Grape growers in Michigan do not agree as to the diameter of cane associated with greatest average fruitfulness, and the general suggestion given by horticultruists that the best canes for the Concord are about the size of a lead pencil seems rather indefinite. The diameters recorded in the table below were measured between the fifth and sixth nodes in each case.

RELATION OF YIELD OF CANES TO THEIR DIAMETER.

Diameter of cane in inches	Average Yield per Node in Ounces, Crop of 1922. Heavy Loam	Medium Loam	Sandy
5/40	1.3 (1)	5.3 (7)	2.7 (15)
6/40	3.6 (8)	5.4 (41)	3.7 (38)
7/40	5.2 (23)	5.5 (47)	4.3 (51)
8/40	6.2 (62)	6.3 (65)	4.1 (51)
9/40	6.5 (66)	7.1 (41)	5.0 (54)
10/40	7.4 (53)	8.3 (29)	5.4 (34)
11/40	6.1 (45)	7.5 (15)	5.1 (30)
12/40	6.6 (24)	8.0 (13)	4.3 (19)
13/40	5.6 (10)	8.2 (7)	4.6 (3)
14/40	5.6 (8)	1.5 (2)	3.6 (1)
15/40	....	7.6 (2)	5.9 (2)

(Numbers in parentheses indicate number of canes from which average is calculated.)

Though curves produced by plotting the above data are rather irregular, they indicate rather clearly that there is an optimum cane diameter, a diameter which is more often associated with productive canes than any of the others, and that this optimum diameter is a quarter of an inch at a point midway between the fifth and sixth nodes.

The association of greater average yield and the morphological characteristics of canes listed above, is probably not a relation of cause and effect. It is conceivable that these morphological changes may be associated somewhat loosely with the internal factors that cause fruitfulness. A knowledge of the external characteristics of the cane is of the utmost importance in placing before the grower any information in regard to the selection of the more fruitful canes. It should also be of as great value in any fundamental study of the internal changes which cause fruitfulness in the Concord grape.

Varietal Differences in Growth of One Year Apple Trees

By A. P. French, *Experiment Station, Amherst, Mass.*

OBSERVATION shows that there are noticeable differences in the size of trees of various apple varieties. It is generally recognized that Baldwin, for example, produces a much larger tree than does Wealthy or Yellow Transparent, yet very little has been done to find out the reasons for these diffenences in growth. With this in mind the problem herein reported was undertaken in an effort to reveal the actual differences of growth between certain varieties, and also to throw light upon the underlying factors which might be responsible for these differences.

The materials used in this study consisted chiefly of one year old nursery trees of the following varieties: Baldwin, Rhode Island Greening, Tompkins King, Delicious, McIntosh, Wagener, Wealthy, Yellow Transparent, Oldenburg, Red Astrachan and in some cases Northern Spy and Fall Pippin. One-year old nursery trees were selected for study because of the similarity of their environmental conditions, the ease with which they could be studied, and the fact that they were obtainable in quantities large enough to largely overcome individual variations. This material was grown in the nursery of J. W. Adams & Sons, Westfield, Massachusetts, on an extremely uniform sandy loam soil. All trees used were grown from budded stocks and only whips which were unbranched and which had not been checked in growth, were selected for study.

Probably the most evident difference between varieties, as they stand in the nursery row, is that of height. *Measurements for this factor are available for the years 1916, 1917, 1921, and

*The writer is indebted to Dr. J. K. Shaw for all data for the years 1916 and 1917.

1922. A comparison of height measurements for these four years shows that there is considerable variation in the height of certain varieties in different years while some varieties are quite consistent from year to year. For example, Baldwin ranges from 150.62 cm. as the average in 1922, to 160.88 cm. in 1921, while on the other hand Tompkins King ranges from 132.46 cm. in 1921 to 179.65 cm. in 1916, and Yellow Transparent was only 97.76 cm. high in 1921 and 148.87 cm. in 1917. The averages of the four years places the varieties in the following order as to height; Tompkins King 164.12 cm., Baldwin 155.98, Fall Pippin 136.86, Rhode Island Greening 136.50, Delicious 136.02, McIntosh 133.58, Northern Spy 133.26, Yellow Transparent 125.94, Wealthy 119.26, Wagener 118.31, Red Astrachan 115.24, and Oldenburg 114.31cm.

Differences in diameter are normally less noticeable than those of height. Diameter measurements were taken about six inches above the ground on the straight wood above the bud. The same tendencies of variation are present in diameter as in height, but to a considerable less degree. The range of variation within a variety may be shown on the one hand by McIntosh with an average of 10.70mm. in 1916 and 11.54 mm. in 1917, and on the other hand by Yellow Transparent which varies from 9.41 mm. in 1921 to 13.72 mm. in 1917. In diameter as in height, it was found that Tompkins King and Yellow Transparent were the most variable of all varieties. However, the other varieties do not necessarily retain the same order of variability. In other words an increased height for a certain variety in a given year does not necessarily mean a corresponding increase in diameter. This fact will be shown later in considering the index of stockiness. Averaging the diameter measurements for the four years gives the following order: Fall Pippin 13.91mm.. Baldwin 13.82, King 13.28, Rhode Island Greening 12.76, Northern Spy 12.24, Wagener 12.11, Yellow Transparent 11.51, Delicious 11.47, Red Astrachan 11.28, McIntosh 11.17, Oldenburg 10.40, and Wealthy 9.82 mm.

A third factor which is more or less related to the first one considered, is that of internode length. This measurement was taken, in all cases, as an average length of ten consecutive internodes of normal growth on each tree, thus giving greater stability to the figures. Length of internode measurements are available only for the years 1921 and 1922, no previous work having been done on this factor. For the two years available, Baldwin and Rhode Island Greening are very consistent in their internode length: the former with an average of 30.97 mm. for 1921 and 30.88 mm. in 1922 and the latter 24.65 mm. in 1921 and 25.22 mm. in 1922. Yellow Transparent on the other hand again shows the greatest variation, averaging 21.85 mm. in 1921 and 27.25 mm. in 1922. An average of the two years gives the following order: Tompkins King 31.85 mm., Baldwin 30.93, Northern Spy 27.29, Oldenburg 25.82, Wealthy 25.56, McIntosh 25.08, Fall Pippin 25.04, Rhode Island Greening 24.94, Yellow Transparent 24.55, Delicious 23.14, Red Astrachan 22.67, and Wagener 21.33 mm.

A comparison of these three sets of measurements, namely height, diameter and length of internode, for the years 1921 and 1922, seems to indicate that length of internode is a more constant factor from year to year than either height or diameter. From this it would appear that length of internode may be governed less by environmental conditions than either of the other two. In other words length of internode is probably, primarily, a hereditary factor modified somewhat by environmental conditions.

Measurements were not taken in such a manner as to permit figuring of correlation between these three growth factors, but a comparison of the averages for 1921 and 1922 shows that there is a somewhat closer relation between diameter and height than between height and internode length. The difference is not great enough, however, to be significant. Apparently little relation exists between lengths of internode and diameter.

Another difference which exists between varieties is that of stockiness. This is found by dividing the height by the diameter. On this basis the varieties may be divided into stocky and slender growing sorts. Considerable difference is evidenced in the stockiness of one variety from year to year and also between different varieties in the same year. As mentioned before an increased height for a certain variety in a given year does not necessarily mean a corresponding increase in diameter. For example, the extremes of variation may be shown by Oldenburg with an index of stockiness of 95.3 in 1921 and 126.7 in 1922, and Baldwin with an index of 109.2 in 1917 and 115.3 in 1921. There are also quite noticeable differences in the average indices of stockiness for all varieties between the different years. The average of all varieties in 1916 was 121.7, in 1917 it was 107.9, in 1921 it was 106.9, and in 1922 it was 112.2. This difference in stockiness of all varieties from one year to another is undoubtedly due to environmental conditions such as differences in plant food available, weather conditions, and the amount of sunshine during the growing season. An average by varieties for the four years places them in the following order; Wagener 97.7, Fall Pippin 98.4, Red Astrachan 102.2, Rhode Island Greening 106.9, Northern Spy 108.9, Yellow Transparent 109.4, Oldenburg 109.9, Baldwin 112.9, Delicious 118.6, McIntosh 119.6, Wealthy 121.4, and Tompkins King 123.6.

Leaf area is another factor which varies considerably between varieties. Comparative area of single leaves was obtained for 1922 by measuring the area of 25 leaves of each variety with a planimeter. In selecting the leaves only one was taken from each of 25 individual trees, care being taken to select equally mature and perfect leaves from the same relative position on the tree. This gave an average individual leaf area for each variety as follows; Wealthy 41.35 sq. cm. Delicious 45.48, Red Astrachan 49.03, Oldenburg 50.06, Yellow Transparent 54.19, Wagener 59.09, McIntosh 63.09, Tompkins King 67.99, Rhode Island Greening 72.24, and Baldwin 72.26 sq. cm. In order to obtain an estimate of the total leaf area of the varieties it is necessary to

multiply the average area of the twenty-five leaves measured by the theoretical number of nodes, which is obtained by dividing the height by the length of internode. This gives a calculated total leaf area as follows: Wealthy 1650 sq. cm., Oldenburg 1837, Red Astrachan 2309, Delicious 2520, Yellow Transparent 2606, Wagener 3002, McIntosh 3293, Tompkins King 3433, Baldwin 3526, and Rhode Island Greening 3605 sq. cm. It is recognized that these are not actual areas, but only calculated, and hence have only a comparative value.

For comparison with the leaf area, the calculated volume of wood produced has been figured. This has been found by multiplying the height by the area of a cross-section half way from base to terminal bud. This calculation gives the following volumes for the varieties studied. Wealthy 16718 cu. mm., Oldenburg 16796, Red Astrachan 25818, Delicious 31403, Wagener 32413, Yellow Transparent 33476, McIntosh 34670, Rhode Island Greening 37262, Baldwin 52156, and Tompkins King 56328 cu. mm.

Comparison of leaf area and volume tends to indicate that generally increased volume is accompanied by, or the result of, increased leaf area, with the exception of Tompkins King and Baldwin which have much greater volume than their leaf areas would seem to justify. For strict comparison, the total weight of wood produced would be much more valuable than volume, because of the fact that there are differences in specific gravity of the wood of different varieties. If specific gravity figures were available, they would probably indicate that increased leaf area is accompanied by increased total weight of wood produced. It is known that Tompkins King and Baldwin have noticeably light soft wood, hence their greater volume in proportion to their leaf area.

Still another method of attack which presented itself was that of measuring the photosynthetic power of the leaves as expressed by the increase in dry weight of samples of leaf tissue. The method here employed was similar to that described by Ganong.* Leaves were covered with black paper envelopes at night. The next morning these envelopes were removed and four disks of leaf tissue, equally distributed over the blade, were cut from each of 25 leaves making 100 disks to a sample. These were placed in a bottle containing 5 c. c. of 95 per cent alcohol and put in the drying oven as soon as possible. A second sample was taken from the same leaves after a period of four or eight hours and placed in the drying oven. The dry weights of these two samples were compared and the increase represented the amount of starch accumulated within the leaf for the given period. Observations on the light conditions were also taken in connection with this work. It is realized that the method used can be criticized for its crudeness, but under the circumstances it is the best that could be had and gives comparable results. The method has been checked in several ways and in no case has

*Ganong, W. F., A Laboratory Course in Plant Physiology—2d Ed. pp. 92-94. 1908.

the error of the method been greater than 25 per cent and in most cases less than 10 per cent of the increase in dry weight of the samples.

Because of the time necessary in preparing the leaves and gathering the samples, figures are available only for the varieties Baldwin and Yellow Transparent. The area of the disks cut was 44.18 sq. mm. or 4418 sq. mm. per sample of 100 disks. The results of six sets of samples for Baldwin and Yellow Transparent are as follows:

	Sunshine	Cloudy
Baldwin	.0278 grams	.0252 grams
Yellow Transparent	.0271 grams	.0158 grams

Of course these figures are merely indicative because of their fewness of number, but if the indication is correct it means that Baldwin accumulates nearly as much starch on a cloudy day as it does during sunshine, while Yellow Tranparent accumulates a little over half as much in cloudy weather as in clear. This seems to be a clue as to why Baldwin produces as much larger tree than does Yellow Transparent. It is hoped that this part of the problem can be extended and enlarged upon another summer so as to obtain reliable figures on several varieties.

Summary

1. Measurements of height, diameter, and internode length for one year old nursery trees show that varieties differ considerably in their variability of these factors from year to year.

2. Length of internode appears to be a somewhat more constant factor than either height or diameter.

3. The relation between height and diameter and height and internode, is about the same, while diameter and internode show no practical relation.

4. The index of stockiness varies in different years for all varieties and also between varieties from year to year.

5. Increased volume of wood produced is accompanied by increased leaf area, except in Tompkins King and Baldwin which have light, soft wood.

6. Varieties studied differ in the amount of starch accumulated in the leaf during clear and cloudy weather.

Water Glass as a Dressing for Pruning Wounds

By W. J. Young, *Experiment Station, Wooster, Ohio.*

WATER glass was first employed as a dressing for pruning wounds in the spring of 1919 at the South Carolina Experiment Station, when preliminary tests were made for the purpose of developing new methods of protecting wounds, owing to the unsatisfactory character of the dressings already in use. Water soluble substances were washed away by rain or the flow of sap, while insoluble materials failed to penetrate or even stick to the freshly-cut, moist surface of the wood. The choice of water glass was made for purely theoretical reasons. It was thought that the penetration would be satisfactory, owing to its soluble character, and that the comparatively thin layer would soon become oxidized on exposure to the air thus sealing the cut surface with an insoluble covering of silica. Even the sap of the plant, it was thought, might aid in the precipitation of insoluble matter.

The very satisfactory result of the preliminary trial upon the Muscadine grape, a species very subject to bleeding from pruning wounds, was reported in a brief paper read before this Society last year. During the past season the experimental work has been continued at the Ohio Station, using a block of Silver Maple trees in the plantings of the Forestry Department. The trees were from two to four inches in diameter and the cuts treated measured from one-half inch up to about two inches. Two or more branches were removed from each tree and the lowermost cut on each tree was left untreated. The branches were removed with a pruning saw making the cut fairly close to the trunk, but no particular pains were taken to do a better job than would be expected in ordinary good pruning practice. The water glass was applied with a small paint brush.

The experiment was designed to test the relative value of the full strength and dilute water glass. Four strengths were used, for convenience designated as 25, 50, 75 and 100 per cent water glass, the strong commercial solution being used as the basis for dilution under the rather misleading term of "100 per cent." The water glass was used both hot and cold at each strength. There were thus eight separate tests, each involving two rows of trees.

The trees were pruned and the dressing applied on March 3, 1922. The weather conditions were favorable for the work. The sky was clear and the temperature slightly below freezing in the morning. There was a thin covering of snow upon the ground and a thin coating of ice upon the branches of the trees which disappeared during the forenoon. The sap started quite freely from the cuts.

The full strength water glass is a sirupy liquid which becomes quite thick at a low temperature. Applying it cold in the winter

or early spring is a difficult and wasteful process and it is doubtful if it is able to penetrate the wood to any extent. On the other hand, heating the solution is unsatisfactory as the water glass is partly decomposed and a refractory scum is formed upon the surface.

On March 6, it was found that cuts treated with 75 per cent and 100 per cent water glass showed practically no bleeding. Where weaker solutions were used, the cut surface was often wet with sap though not much sap was escaping. It was noted that a single treatment had not been sufficient to completely seal over the surface in those cases where the sap was flowing freely when the dressing was applied. Heating had not apparently affected the success of the treatment. Ten days later three large cuts which had been covered with cold water glass at full strength were wet with sap while the hot treatment had been 100 per cent successful. The 75 per cent water glass, both hot and cold, gave nearly a perfect score. The more dilute solutions were not so successful, though the bleeding was greatly checked. On this date sap was flowing freely from the untreated cuts except where they were very small. On April 6 all cuts, both treated and untreated, were dry.

The trees were examined from time to time through the summer and the healing processes were noted as proceeding normally and favorably in all cases. By the end of the growing season a well developed callous had formed around the cuts and was beginning to cover them at the edges. There was no evidence of injury to the cambium by the water glass as there was equally vigorous callus formation around the wounds whether treated or not. The cut surface of the wood was dry, hard and sound. Unfortunately it was not possibe to make sections showing the condition of the wood to the heart of the tree. One stub was found, however, where the cut had been made at such an angle that the callus could not cover the surface readily, and the bark had died back on the outer side of the cut to the level of the tree trunk where a callus had been formed, leaving exposed a triangular section of dead wood, the outer side of which had not been protected by the water glass. This section was removed with a sharp knife. Upon splitting longitudinally it was found that the wood at the surface exposed in making the original cut and afterward protected by the dressing, was sound, but that decay had entered from the side lower down, the unsound, discolored wood spreading inward and then upward in streaks toward the surface.

In our work the present season, we have been fortunate in having the cooperation of a tree repair and landscape gardener who has used the water glass in practical tree surgery. The following report was received under date of November 2: "I find water glass very successful, but find old and decayed bark must be cut away before water glass is applied."

It remains to speak of plans for further experiments with water glass. In the first place it is intended to secure for

treatment trees which can afterwards be cut up so as to show the condition of the interior of the wood at various periods after the treatment. It is important to determine how much resistance the water glass may offer to the entrance of wood-destroying fungi. The water glass itself has slight antiseptic properties due probably to its alkalinity. This property is doubtless only temporary and would probably dissappear as the water glass turns to silica. Experiments are under way to learn if the water glass can be combined with a disinfectant.

It is well known that silica forms insoluble salts with the heavy metals.. Thus when a solution of copper sulphate is added to water glass a gelatinous blue precipitate is thrown down. It has been suggested that this substance might be available for use as an antiseptic paint for wound treatment. The reaction with mercuric chloride seems to vary somewhat with the concentration of the solutions. We wish to find out whether it is possible to prepare a stable antiseptic dressing containing mercuric chloride and water glass. We also wish to know what sort of mixtures may be made with water glass and the various organic disinfectants. Inoculation experiments should then be made with the spores of wood-destroying fungi to learn how much resistance these various mixtures and compounds offer to the entrance of such fungi, and for how long a time a single application is effective.

In conclusion we feel that we are justified in the belief that water glass is the most effective dressing so far devised for the treatment of all kinds of wounds and injuries upon woody plants. This has been demonstrated experimentally, and to a limited extent in practical tree surgery. It is not necessary to use the water glass full strength. A solution containing one part of water and three parts of commercial water glass is more economical and appears to penetrate the pores of the wood surface better, especially in cold weather and thus more effectually seals the cut. Large wounds from which sap is flowing freely may require more than one application to be effective. Before treating injuries, the surface should be trimmed smooth and dead bark and decayed wood should be removed. Branches should be removed by a smooth cut, parallel to the surface of the trunk and close enough so that the callus may easily cover the wound. Experiments have reached a point where we believe that the method may be safely recommended for trial to tree surgeons, landscape gardeners, fruit growers and any others who might find it useful.

Preliminary Report of the Root Systems of Grape Varieties

By A. S. Colby, *Experiment Station, Urbana, Ill.*

IT has been shown by the extensive experiments of Weaver, Jean and Crist, in "Development and Activities of Crop Plants," that an exact knowledge of root development of plants, their position, extent, and activity as absorbers of water and solutes at various stages of growth, is of paramount importance to a scientific understanding of plant production. Again, it is held that a knowledge of modifications produced by variations in subterranean environment, whether due to natural conditions, as excessive water content or drought, or to tillage or fertilizers is no less important. In fact many processes and practices will cease to be empirical and come to be exact when the relation of roots to soil is recognized as having fundamental value.

In an effort to gain a more complete knowledge of the root development of some of our common small fruits on which to base a more intelligent system of soil practices, preliminary work has been undertaken at the Illinois Station with special reference to root systems of representative grape varieties. It is proposed to extend the investigation to include all the common small fruits as soon as possible. Some interesting data have already been obtained and are briefly presented at this time, with tentative conclusions.

The grape vines whose roots were exposed are growing in the variety vineyard at the Urbana Station. The soil type is the morainal brown silt loam commonly found on an eastern exposure in that locality. Representative soil strata encountered as excavating proceeded follow in order, with their approximate depths; silt loam two feet; yellow silty clay two and one-half; clay two feet with sandy, gravelly drift below. The water table is within approximately two feet of the surface. An average annual rainfall of 36.89 inches is reported by the Experiment Station records for this section.

The vines, two year old, were all planted in the spring of 1917 so have finished their sixth growing season. The four arm Kniffen system of training has been followed. Soil treatment has included clean cultivation, followed the last three seasons with cover crops of rye, wheat, and vetch, respectively.

In the process of uncovering the roots, after the first few inches of soil was removed with a spade, it was found necessary to use a fork and a hand trowel since the feeding roots were encountered quite generally from a depth of six inches. From a depth of four feet down it was often necessary to use a pick to loosen the soil.

The Concord vine examined illustrated the two story root system, the first two laterals of the upper story being found two

inches from the surface, and the third, one inch deeper. These radiated out two feet six inches, three feet ten inches, and four feet three inches, respectively, in a horizontal manner. One branch 2 feet and 7 inches long was found arising from the third lateral. A few fibrous roots were present. There was evidence of injury to these roots by tillage tools. The lower portion of lateral roots, 12 in number, arose at a depth of from 7 to 10 inches below the soil surface and varied in length from 12 feet 3 inches to 17 feet 10 inches. These laterals were fairly uniform in depth, about 8 inches, throughout their length, with one exception. In this instance the root grew out horizontally a distance of four inches from the trunk, then plunged downward to a depth of 5 feet 1 inch, extending horizontally thereafter 18 feet. Eleven branches arose from this lateral and grew up toward the more fertile soil stratum. Extensive branching occurred on the laterals at a depth of 8 inches. Fibrous roots were abundant so the space between laterals was quite well filled. The roots have a feeding radius of 16 feet. The greatest depth at which roots were found was 5 feet 9 inches.

The Worden grape vine examined showed 10 vigorous laterals originating on the trunk at a depth of from 5 to 8 inches. These grew out horizontally in different directions for distances varying from 7 feet to 10 feet 7 inches, before striking downward to an average depth of 5 inches, with one exception. This root grew horizontally 2 feet 7 inches then vertically to a depth of 5 feet. The Worden was characterized by an extensive branching development from the main laterals, ending in masses of fibrous roots. There were no branches found on the laterals in the first 8 inches of soil, but they were found in increasing numbers as the lower soil strata were reached.

A vine of Delaware again illustrated the two story rooting system, the upper story being composed of 5 lateral roots originating at a point 4 to 6 inches below the surface and radiating out horizontally at an average depth of 7 inches to a maximum of 10 feet in length. The lower group of roots, 3 in number, originated at about 11 inches below the surface and after a period of horizontal growth varying from 2 feet 2 inches to 12 feet struck deeply downward, the greatest depth measuring 7 feet 8 inches. The root system had a feeding radius of 11 feet 6 inches. The feeding area was about one-half filled with absorbing roots, and although a considerable number of fibrous roots was found along the top group of laterals, very few branches arose from them. At a depth of three to five feet in the silty clay, laterals branched quite generally the branches turning downward.

The Clinton revealed a vigorous root system with a feeding radius of 21 feet 9 inches and a total depth of one root of 6 feet. The laterals arose from the trunk at an average depth of 10 inches. There seemed to be no uniformity in direction of growth—some radiating out to an average distance of 1½ feet then abruptly turning downward to a depth of 5 feet, while others grew out to a maximum distance of 21 feet 9 inches, then worked down only 18 inches. While there were many fibrous rootlets found on the

laterals, branching did not occur till the yellow silty clay was reached.

The vine of Norton was the most vigorous examined, the roots being thick and tough with a feeding radius of 20 feet. Ten laterals arose from the trunk at a depth of from 5 to 10 inches. Those on the north side of the vine radiated out to a distance varying from 16 inches to 7 feet, then struck abruptly downward to from 3 feet 10 inches to 5 feet 3 inches. Numerous laterals branched from these vertical roots from a depth of 3 feet down in the silty clay. The remaining 4 roots with south and southwest exposure behaved very differently than those mentioned above in that they grew horizontally for distances varying from 9 to 14½ feet, then struck downward to from 5 to 9 inches. The greater number of branching roots on all the laterals arose at right angles, seemingly an individual peculiarity. The greatest root depth was 6 feet, 1 inch.

It was noted that the size and distribution of the root systems of different varieties was to a certain extent characteristic. Concord and Worden, representing the labruseas, have a more extensive root growth in the upper soil strata than the Clinton of vulpina parentage, or the Norton of æstivalis parentage. These two latter varieties tend to feed extensively at a greater depth. The Delaware of labrusca-borquiniana-vinifera parentage, with a comparatively small horizontal feeding area, reached the greatest depth of any variety examined, 7 feet and 8 inches. It is of course understood that the root systems of the varieties studied will increase year by year and it appears that the increase will be considerable.

Husmann in his "American Grape Growing and Wine Making," has noted the comparatively shallow rooting system of labruseas, while Hedrick, in "Manual of American Grape-Growing," states that the roots of vulpina feed close to the surface and do not seem able to force their way through heavy clays. These statements are not borne out by the facts in this locality.

It is very probable that the root development described was greaty dependent upon many environmental factors according to Gardner, Bradford and Hooker, in "Fundamentals of Fruit Production." "Within certain limits the size and general character of top growth are influenced by the root system that supports it. Similarly the size and distribution of the root system depends to an important degree on the moistened content of the soil." It is also probable according to Weaver that the root system, as far as it regards the number and length of roots, is connected with the development of the shoot.

Naturally an extensive root system with a deeply rooting portion, is very desirable, if the plants are to successfully endure conditions of drought and produce high yields—grapes of all varieties examined fulfill that requirement for this locality. There was an entire absence of tap root noted on any variety examined. It also appears that while the roots are primarily absorbing agents they serve as a means of support for the vine with the aid of the trellis.

It is concluded with the preliminary evidence at hand that a number of present cultural practices in the vineyard need modification. Deep cultivation, especially near the trunk inevitably breaks off or injures lateral anchor roots. Cultivation, however, is needed nearer the trunk than with most large fruit plants because of the numerous feeding roots close in. Grapes should be set no nearer than 10 feet, preferably 12 or more feet square under conditions similar to those at the Station. The deep and extensive rooting system found explains in some measure the conflicting results secured in earlier fertilizer experiments. It will be possible to more intelligently work out control measures for certain grape insects, as root worm and phylloxera, as root systems are better known. The fact that extensive root activity was noted at extreme depths in the yellow clay indicates that we will need to include lower strata than usual in taking root samples for moisture and plant food.

We must, therefore, conclude with Weaver et al. that deeper soils are not only suited to plant life, but that they play an exceedingly important part in the life of plants and deserve careful consideration in a study of crop production.

Fruit Bud Formation in Rubus and Ribes

By L. H. MacDaniels, *Cornell University, Ithaca, N. Y.*

THE fruiting habit and the time of fruit bud formation of the apple, the pear, the peach and the cherry, have been studied more or less intensively in different parts of the country by a number of investigators so that at present they are reasonably well understood. With the exception of the work of E. S. Goff at the Wisconsin Station, however, the bramble fruits and the currants and gooseberries have received little attention in this regard. The present study was begun in the summer of 1914 and carried on during the next three summers with the purpose of finding out more definitely the time of fruit bud formation and the nature of the buds on the different parts of the blackberry and raspberry canes.

The procedure was along two lines, namely that of bud examination and pruning. In the bud examination, buds were collected at different intervals and examined by dissection under a binocular microscope. The dissection method made possible the examination of a large number of buds and, where differentiation of flowers was well under way, was entirely satisfactory. The magnification (about 15 to 20) was not sufficient to determine the differentiation of the growing point in the very early stages. In the pruning work, during one season different proportions of the rubus canes were cut off and the results noted, and during another, the canes were pruned to different numbers of buds.

BUD EXAMINATION.

Black Raspberry, var. Cumberland

Collection	Condition
July 20, 1914	Growing points not differentiated.
Aug. 16, 1915	No visible differentiation.
Sept. 16, 1915	No visible differentiation.
Oct. 6, 1915	Apparently the beginning of differentiation.
Jan. 11, 1915	Flowers well differentiated but zones not.
Feb. 20, 1915	Flowers differentiated about as in previous collection. Terminal flower the largest.
Mar. 3, 1917	No observable difference from February collection.

From this series of collections, it appeared that the flowers differentiated in the late fall, probably during early October.

Red Raspberry

Date of Collection	Variety	Condition
July 20, 1914	Marlboro } Cuthbert }	No differentiation of growing point into flowers.
July 31, 1914	Cuthbert	Same as above.
Aug. 16, 1915	Herbert	Same as above.
Sept. 16, 1915	"	Same as above.
Oct. 6, 1915	"	No apparent differentiation.
Jan. 11, 1916	"	Growing point only partially differentiated. Flowers not clearly formed.
Mar. 3, 1917	"	Flowers differentiated, but very small—much smaller than with the black raspberry at the same season.

Indications were that flowers were only very imperfectly differentiated in fall in the red raspberry, being much behind the black raspberry in this regard. Collections of the *Golden Queen raspberry* made August 16, September 16, October 6, January 11 and February 20, showed no certain differentiation of the flowers. The condition was in every case about as in the Herbert red raspberry. Buds of the winter collections were large and well formed, but dissection revealed no well formed flowers.

Collections of the Columbian purple cane raspberry made October 6 showed no well defined differentiation of buds. January 11 and February 20, collections showed probable beginnings of differentiation. Collection of April 4 before buds opened showed flowers well formed in both axillary and superposed buds. The development of the flowers of the purple cane raspberry was more nearly like that of the red raspberry than the black.

Blackberry

Date	Variety	Condition
July 31, 1914	Eldorado	No differentiation.
Aug. 16, 1915	Snyder	Leaves only differentiated with certainty. Possibly the beginning of one terminal flower.
Sept. 16, 1915	"	Flowers clearly developed.

Oct. 15, 1915	"	Flowers clearly developed. Receptacle of terminal flower corrugated with young pistils.
Jan. 11, 1916	"	Flowers well developed—only very slightly larger than October collection.
Feb. 20, 1916		Same as January collection.
Mar. 3, 1917	"	No change from February collection.

It is quite clear that the flowers of the Snyder blackberry differentiate about the last of August. There is little change taking place between September and March.

Houghton Gooseberry

Date	Condition
Aug. 16, 1915	Growing point just beginning to differentiate into flowers. No floral parts visible.
Sept 16, 1915	Small flowers clearly differentiated.
Oct. 6, 1915	Floral parts showing, but small.
Jan. 11, 1915	Floral parts clear, stamens with anthers.
Feb. 20, 1916	Same as January collection.

The same collections were made and examined with the variety Columbus, which showed later development by about ten days or two weeks. The growing points of the gooseberry differentiated into flowers about the first week of August. With the gooseberry, bud examination is somewhat unsatisfactory since about half of the buds are leaf buds and would never develop flowers.

Cherry Red Currant

Date	Condition
Aug. 16, 1915	Growing points differentiated into flower clusters, but no flower parts developed
Sept. 16, 1915	Flower clusters well developed Flower parts beginning to form.
Oct. 6, 1915	Floral parts showing, but small
Jan. 11, 1916	Sepals, petals and stamens visible, beginnings of a pistil.
Feb. 20, 1916	Same as January collection.

Indications are that flowers differentiate about the last of July, or the first of August.

PRUNING EXPERIMENTS

Cumberland Black Raspberry, Pruned March 29, 1916.

Each treatment included 10 canes selected for uniformity from a continuous row of plants. The canes had been pinched back the previous season so that all were branched. Five different treatments were given as follows:

1. Not pruned.
2. Side branches cut back one-half.
3. Side branches cut back three-fourths.
4. Side branches cut off flush with main cane.
5. Canes cut to stubs 6 to 8 inches high.

Observation on May 20, 1916, showed blossoms well formed on all sets of plants. The canes with the most severe pruning showed stronger vegetative growth and delayed blossoming.

EXAMINATION—JULY 17, 1916.

1. The unpruned vines showed tips of side branches dead from winter killing. Fruit from practically all buds except near tips of branches and base where buds did not start.
2. Fruiting well from all buds from base to tip. Best fruit just back of tip.
3. Fruit from all buds. Some canes not in good condition due to anthrachnose.
4. Large fruits on vigorous shoots from each node. These fruits in some cases came from small buds which were at the bases of the lateral branches. Very vigorous growth of new canes from roots. Berries large and of good quality.
5. This set partially destroyed by cutivator. All buds appeared to be potentially flower buds.

HERBERT RED RASPBERRY

Pruned March 29, 1916.

1. Not trimmed.
2. Canes cut back one-fourth to one-third.
3. Canes cut back one-half.
4. Canes cut back three-fourths.

Examination on May 5 showed flowers from practically all living buds. The severely pruned canes produced long vegetative shoots which blossomed later than the others.

Examination on July 7 showed fruit from all buds from base to tip as with the black raspberry. Where pruning was light, basal buds did not start at all. All buds were apparently potential flower buds.

MARLBORO RED RASPBERRY

Pruned in the same way as the Herbert except that a fifth set of canes was pruned to stubs about one-fifth the length of the original canes. Observations showed the same conditions as in case of the Herbert. The buds from the base of the canes cut to stubs produced long shoots terminating in small clusters of large fruits. All buds were potentially fruit buds.

SNYDER BLACKBERRY

Canes pruned on March 29, 1916.

1. Unpruned.
2. Side branches shortened one-fourth.
3. Side branches shortened one-half.
4. Side branches entirely removed.
5. Canes cut to stubs.

Examination May 20 showed flowers from nearly all buds on all sets except No. 5.

EXAMINATION ON JULY 17.

1. Fruit on practically every shoot from tip to base. Some buds at base not developed.
2. Same as 1.

3. Practically all buds from tip to base with fruit. Basal buds with fewer fruits than upper.
4. Some fruit from upper nodes. Basal buds forced into strong vegetative growth. New canes from roots very rankly vegetative smothering growth from fruiting canes.
5. No fruit developed. Very rank vegetative growth.

The basal buds appeared to be leaf buds, or at least to be undetermined and forced into vegetative growth by the severe pruning. The basal buds of the blackberry were more often entirely vegetative than either of the raspberries.

Minnewaske Blackberry

Pruned March 29 making five different treatments as in the case of Snyder.

Examination on May 20 showed no difference from the Snyder.

Examination on July 17 showed a condition like that found in the Snyder except that in the case of set 5, where the canes were pruned to stubs, some of the buds had developed into vigorous shoots terminating in a few spindling blossoms. The strong vegetative growth of the new canes from the roots undoubtedly interfered greatly with the growth of these basal buds.

Snyder Blackberry

Sets of 10 canes each pruned March 3, 1917, to 18, 12, 9 and 6 buds respectively.

Examination on July 18, 1917.

Set 1, 18 buds, the maximum number to be found on any considerable number of canes. Each cane listed separately. Buds numbered from tip of cane to base.

Cane 1. Fruit from buds 1 to 6, 8 to 9. Buds 7, 10 to 13 with healthy leafy shoots -others weak vegetative shoots.
2. Fruit 1-12, 13-15 a few berries, 16 to 17 vegetative, 18 not developed.
3. Fruit 2 to 6, 8 to 9. Vegetation 1, 7, 10 to 12. No buds developed below 12.
4. Fruit 1 to 13. Strong vegetative 13 to 18.
5. Fruit 1 to 8, 10-12. Vegetative 9, 13, 14, 17.
6. Fruit 1 to 11. Vegetative 12-17.
7. Fruit 1 to 10. Vegetative 11, 12, 13, 15.

Set 2. 12 buds, July 18, 1917.

Cane 1. Fruit from buds 1 to 4. Vegetative 5 to 12.
2. Fruit 1 to 4, 6. Vegetative 5 to 12.
3. Strong cane. Good fruit from superposed buds 1 to 5. Vegetative shoots from axillary buds. Nodes 5 to 12 strong vegetative from axillary buds. Few fruits from superposed buds 5 to 9.
4. Fruit 1 to 4. Vegetative 5 to 12.
5. Fruit 1 to 7. Vegetative 8 to 12.
6. Fruit 1 to 4. Vegetative 5 to 12.
7. Fruit 1 to 4, 6 to 8. Vegetative 5, 9 to 12.

Cane 8. Fruit 1 to 4, 7 with a single fruit. Vegetative 5 to 12. Vegetative shoots on nodes 1 to 4 in addition.
9. Fruit 2, 3, 5-6, 8. Vegetative 1, 4, 7, 9, 10. Strong vegetative on 2 in addition.
10. Fruit 1 to 7. Vegetative 8 to 12. Vegetative on 6 also.

Set 3. 9 buds. July 18, 1917.

Cane 1. Vigorous fruit clusters on 1. Blossoms on shoots from 8 and 9. Other shoots vegetative.
2. Strong cane from which side branches had been cut. Fruit from node 1. Vegetative shoot also. Others entirely vegetative except blossoms on 8.
3. Fruit 1 to 6. Vegetative 7 to 9.
4. Fruit 1 to 2. Blossoms 4. Others vegetative.
5. Fruit on 1 only. Others vegetative. Strong cane from which side branches had been cut.
6. Fruit 1 to 4. Blossoms 6. Others vegetative.
7. Fruit 1 to 4, 6. Others vegetative.

Set 4. 6 buds, July 18, 1917.

Cane 1. Few fruits from superposed buds 1 to 3. Strong vegetative growth from all nodes.
2. Side branches cut off in pruning. All vegetative.
3. Weak cane. Fruit 1 to 3, 6. Others vegetative.
4. All vegetative. Smothered with new growth from roots.
5. Fruit 1. Blossoms 4. Others vegetative.
6. Fruit 1 to 4. Others vegetative.

Set 5. All visable buds cut off March 3, 1917. Examination on July 18, 1917.

Cane 1. 2 clusters of fruit, abundant vegetative growth.
2. Vigorous shoots from nearly every node. 2 to 3 berries at tip of each.
3. Strong shoots from three-fourths of nodes. Blossoms buds at tip of practically every shoot.
4. Vegetative growth from about half of nodes. 1 fruit cluster from bud probably missed.
5. No growth from upper nodes, vegetative growth from lower.
6. Vegetative growth from three nodes. A few fruits from upper nodes.
7. Vegetative growth from about one-half of nodes.
8. No growth from buds 1 to 6. Other nodes strongly vegetative with some fruit at tips.

Cumberland Black Raspberry

Five sets of 10 canes each pruned March 3, 1917, to 35, 25, 18, 12 and 7 buds respectively. Examination of buds from each set by dissection showed probable flowers in practically all.

Examination July 18, 1917, showed somewhat the same condition as in the Snyder blackberry in that with the longer canes the best fruit developed from the upper buds and the lower failed to start growth. Where the canes were much shortened all buds were forced and with few exceptions set fruit. All buds were apparently fruit buds or had the ability to produce fruit, even

down to the base. Shortening the canes increased the vigor of the new growth to some extent, but not so much as in the case of the blackberry. Pruning to shorter stubs killed the canes in some cases. Possibly death was due to some other cause than pruning.

The set of canes with all visible buds removed in March died with the exception of a few shoots.

Herbert Red Raspberry

Five sets of 10 canes each were pruned March 3, 1917, to 25, 18, 12, 9 and 5-7 buds respectively. Canes with 25 buds had practically no pruning. Buds examined from each set showed probable small flowers in all buds though not such clear differentiation as in the black raspberry. Buds below the middle of the cane were farther advanced than those above.

Examination July 18, 1917 showed conditions much like the black raspberry. Any bud from tip to base of cane was potentially a fruit bud, though the lower buds failed to start with the longer canes. Basal buds when forced into growth by severe pruning showed late blooming as if blossoms were probably not well formed during previous season. Strictly vegetative shoots were much rarer than with the blackberry. New growth was greatly stimulated by severe pruning and was frequently a detriment to the normal fruiting of the basal buds on the severely pruned canes.

The set of canes with the visible buds removed on March 3 died, except for straggling growth on a few canes. This was in contrast with the Snyder blackberry, the canes of which lived in most cases and frequently bore fruit.

The above observations suggest that with the bramble fruits all buds are potentially fruit buds. A large proportion of the buds, with the possible exception of those at the base of the cane, differentiates into flowers the season previous to fruiting. Buds with growing points not differentiated may either form terminal flower clusters and bear fruit a week or more after the normal season, or, as is frequently the case of the blackberry, may form vegetative shoots only. The fact that some varieties of raspberries fruit in the fall at the ends of the current season's canes, also indicates that the vegetative shoots are not determinate, but may or may not form fruit buds according to conditions.

Acknowledgement is made to Dr. W. H. Chandler of the Department of Pomology at Cornell University, under whose direction this investigation was initiated and carried on.

Selling Research to the Farmer

By W. S. Brown, *Experiment Station, Corvallis, Ore.*

In most of our state experiment stations, there hovers over some of the best research work the menace of discontinued appropriations, suspension of the work and, possibly, the sacrafice of the worker himself. This baneful influence is felt more at some times

than at others—especially just before the legislature meets—but it is always there, nevertheless, and has much to do with the formation of policies, the outlining of new experiments and so on. If the experimenter cannot be reasonably sure of bringing to a conclusion anything more than short, somewhat superficial problems, that type of work is likely to be chosen rather than the deeper and more far-reaching problems of research work that must of necessity extend over a much longer period of time. Laboratory conveniences and experimental equipment are not built up in a substantial and thorough way under such circumstances, and investigators of ability cannot be induced to take a chance in an institution where this menace may swoop down like a bird of prey at varying intervals.

How, then, to banish this evil of uncertainty, is the problem which the writer wishes to consider for a few moments.

The Farmer's Viewpoint

Let us face the facts! The farmer is supposedly the chief beneficiary of our research work. Whether we get our appropriations necessary for this work or not will depend very largely upon his attitude. The "horny handed son of toil" (as the politician would say) is now engaged in one of the bitterest struggles to keep his head above water that has come to the lot of any man. One cannot be accused of radicalism who simply states what public spirited men in all walks of life have come to realize: that the farmer is being taxed out of proportion to his wealth; that he frequently suffers at the hands of selfish or undiscriminating tariff tinkerers; that poor crop years take their toll; that high freight rates have become a serious menance; and that the lack of successful cooperative organizations in most sections means a wasteful and unsatisfactory distribution and marketing system. Is it any wonder the farmer is not in a happy frame of mind at the present time?

Yet, in spite of these difficult times, the farmer is willing to back to the limit all lines of thought and research which he sees directly benefit him. He must be shown, that is all; and some of our best and most far-reaching experimental work is not easy to put before him in a way that will make him realize its importance. This realization, however, must come to the farmer, or the lack of appropriations will jeopardize the work of the experimenter more than ever before.

How is the entente cordial between farmer and experimenter to be established? By whom, or by what agencies, is the importance of research findings to be brought to the farmer? The extension service may say at once "That is my job," and the college of agriculture may say " I can be of help in this matter by instructing students and sending them out with the information." Both of these statements are true in a measure, and both the college and the extension service should be used to the limit in publicity work; but the party most vitally interested is the experiment station and it should find a way of selling the information it has obtained in a thorough and forceful manner.

Value of a Label

In manufacturing and merchandising, "good will" is considered one of the greatest assets of the business. In the sale of a business, "good will" is often given a definite monetary value, recognized both by seller and purchaser.

How is "good will" brought about? How can such an intangible thing as the desires of humanity be capitalized? The reason for this is simple. People keep on buying the things they have found, from their own experience or the experience of others, to be good. This "repeating" is not only a mark of confidence in the house that sells the goods, it is also a recognition of the importance of advertising the goods properly. The one factor that makes it possible to accurately advertise is the label. An attractive or striking label means so much to the business that many dollars are spent every year in originating clever and original ones. Such labels as "U-need-a" biscuit, "There's a Reason," "Gold Dust Twins," "Skookum" apples, "Mistland" prunes, "Sun-Maid" raisins, contain tremendous potential values for their owners.

To bring this discussion back to research work, the experimenter is, in a way, much like the merchant, he has something to sell to the farmer and to other tax payers, and he must have their "good will" if he is to continue to turn out his products. To do this, he should market his wares under a label that is, or is to become, well known for its reliability and, in addition, for its attractiveness. This label may be the name of the state experiment station, the United States Department of Agriculture, or some technical institution. No matter what the label nor how beautifully designed, the goods covered must be dependable. For it is a law in advertising that a label is a two-edged sword that fights for the product if the quality is good, but turns against the commodity if the quality is poor.

Another axiom of good advertising is that the label must be put before the public prominently in a way that can be easily visualized and understood. Today some experiment stations are forgetting this axiom and are not placing their label before their people as prominently as they should. Perhaps it is the state college that has the largest and most attractive poster on the bill board, perhaps the extension service may have the enviable position. In either case the station is being hurt indirectly at least.

The state colleges are doing a great work for the young people of our country and, naturally, the parents have the college and its welfare in their thought. Results of experiment station work have been handed out to the people by the extension service so often that there is a disposition on the part of some to take this information as a matter-of-course and forget its source. In both of these cases, the experiment station which is the originator of most of the technical subject matter taught in the college and sent out by the extension service, is kept in the background and unappreciated by the work-a-day public. This is in no way a criticism of the excellent work of the college or of the exten-

sion service because no attempt, as a rule, is made by either of them to cover up or to disparage the work of the station. They take, very naturally, all the advertising that belongs to them without being greatly exercised as to the effect of this advertising upon the station. It simply shows that the experiment station must blow its own horn if people are to know it plays in the band.

To illustrate the point with examples most familiar to the writer: lime-sulphur was first developed as a control for apple scab at the Oregon Station. It would be hard to estimate how much the State of Oregon and whole world owes Dean A. B. Cordley who discovered this universal remedy. This Station has contributed in the past and is still contributing much of value to our knowledge of the principles underlying successful pruning. It is estimated, conservatively, that these pruning investigations mean a gain of more than a half million dollars annually to the fruit growers of Oregon. The loganberry industry was in sore straits to get rid of its product at a profit some 10 years ago. An S. O. S. call was sent out to the Exepriment Station. Research work was carried on in the production of a palatable and profitable juice, with the result that the commercial output of loganberry juice now amounts to over a half million dollars each year on the average.

In spite of these and many other pieces of research work, the needs of the Agricultural College, the Extension Service and the Experiment Station of the State of Oregon two years ago seemed badly scrambled in the minds of the people and in the minds of the legislators as well. The result was that, in order to obtain of passage of the horticultural and crop pest bill upon which a large amount of experimental work depended, it was necessary, first, to convince, in private conferences, several of the most influential fruit growers of the fact that the money asked for was absolutely necessary to prevent disaster to the fruit industry of the state; and second, for these growers, after they had become convinced, to wait upon the Ways and Means Committee and upon other legislators to show them that special appropriations besides those voted for the College and Extension Service were needed to carry on the work. After this need had been thoroughly and effectively shown and misapprehensions had been removed, there was little further trouble in getting the matter through the legislature. At no time did there seem to be a desire upon the part of legislators to cripple the station work; they simply had to be shown that this work could not depend for its funds upon money set aside for maintaining other parts of the same state institution.

This and other experiences with the legislature convinced the Oregon station staff that something must be done to advertise the station before the people. Since then the station label has been placed upon every product turned out by members of the staff, and the consumers of these products, the farmers, have seen a wider and more comprehensive piece of advertising than ever before attempted.

Station Letters

Probably the product that is most perishable, that must be marked "fragile," "handle with care," that goes stale in cold storage, and must be devoured when strictly fresh if there is to be no come-back from the consumer, is station correspondence. The label is important here, too. It serves to fix the quality of reliability, or the opposite, in the mind of the recipient. If the tone of the letter is conservative, if the facts described are based upon experimental data, the facts will be well received, and acted upon. When, however, the information is founded in large part upon the opinion of someone, no matter how shrewd at drawing inferences he may be, there is danger that the material contained in this letter may come back like a boomerang to hit the man who sent it out. Research men cannot be too careful in respect to loose thinking. In these days there is altogether too much guess work, too many unworkable theories going into print, without having the experimenter indulge in fancies.

It is a practice in many institutions for experimenters to send out letters signed with name and tittle, but with no reference to the experiment station. The man receiving such a letter, not being familiar with the organization at the state institution, may infer that the information came from a college, or extension employee. When the name of the experiment station is signed first, followed by the name of the writer and his title, there can be no mistake in the matter. Readers see at a glance that a station worker is responsible for that letter and it gives the station greater importance in their eyes.

Newspaper Publicity

Well directed and sympathetic newspaper publicity is one of the best ways in which to put research work across with the public. This information should be so well prepared and so varied in its character that not only the country weekly in the smallest hamlet, but also the largest metropolitan daily can run something of interest for its readers. Timely hints regarding the treatment of gardens, insect pests, shade trees, poultry, the prize pig, and so on, seem to be perennially filling the needs of some one. Longer articles, well illustrated, descriptive of this or that activity of experimetal work, when written in popular vein, are well received by the best papers in the land for regular editions, or for Sunday supplements. Publicity of this sort, is, undoubtedly, the most widely spread and the lowest in cost.

To make newspaper publicity most effective, it should be carefully edited and the experiment station label should be attached in an attractive way. The station editor responsible for this work should be one of the strongest men on the staff.

Another illustration from Oregon may not be out of place here. The College of Agriculture has a school of Industrial Journalism. One of the leading teachers in this school has charge of most of the newspaper publicity for the Experiment Station, the Extension Service, and the College. He is a man of wide newspaper acquaintance. He gets special articles from research

men, dresses them up in the usual coat of newspaper verbiage and feeds them to the different papers to fit the needs of the respective communities served and to satisfy the idiosyncrasies of the various editors, whom he knows well, personally.

Many students in agriculture elect the fundamental courses in Industrial Journalism. These students are entrusted by the station editor with the job of obtaining "farm pointers" and a few longer stories from the members of the staff. After this information is written up it must be O K'd by the man who gave the interview before it can be published. The station label goes on these "pointers," if they are based upon station facts.

This has proved an excellent arrangement both for experimenter and student. It may be added, in passing, that in the few years journalism has been offered these agricultural students, it has worked a transformation in them. They know how to go after information, how to discriminate in their thinking, and how to put their thoughts on paper in the most forceful way. No young man or woman preparing for a career in research should neglect, in these times, to take the fundamentals in journalism when such a course is offered. Many a careful experimenter is hiding his light under the bushel of "lack of expression."

Station Bulletins

The chief object in writing a bulletin, outside of the recording of reliable facts, is to do good with the contents. That means, first of all, that the bulletin must, at least, be read. The bulletin that is needed for the research man combining the technical terms with a detailed description of methods leading to the findings, usually does not appeal to the farmer. Therefore, this paper will not deal with technical bulletins or journals.

What the farmer appreciates is a simple well-written statement of the situation and the facts, together with deductions telling him how best to solve his own problem.

This class of bulletins and circulars is known as "popular." They may be divided into three of four different divisions. (1) the popularized resumé of a technical bulletin usually put into this mold by the editor, or some other qualified person. (The popular bulletins of the Geneva Station have become widely known.)

(2) The more important experimental methods and results of a piece of research, frequently with a digest attached.

(3) Circulars covering briefly smaller problems, or a phase of some larger problem. The information in full, or in part derived from, the station findings.

(4) Bulletins giving few or not any new experimental results, but containing advice for farmers based upon research work either by the home station or by other experimenters.

No one would dispute the right of the station to publish bulletins or circulars in the first three classes, but when the fourth class is handled by this agency some may raise the objection that such a bulletin covers little or not any new experimental ground and should, therefore, be put out by the extension service. But what is going to happen if extension does not have enough funds

to publish much needed information? Should it be held up indefinitely on that account? The Oregon Station has taken the position that when information is needed it should go forward to the people. If the extension service has funds it should publish the work, if not, the material should be sent out by the station provided funds are available. Further, if, as frequently happens, an extension bulletin is written by a research man, the experiment station should be mentioned together with the title of the writer.

There is a natural tendency upon the part of a careful and conservative experimenter to delay publication until his problem has been sifted to the bottom. While this attitude of mind is thoroughly commendable in most cases, circumstances often arise when it may be necessary, in order to avoid serious losses, to tell the people as much as seems safe, based upon the work accomplished. Progress reports should be safe-guarded by statements plainly made that the work is incomplete and that some revision may need to be made later.

As an example of unfortunate results of withholding information, the case of the cranberry growers of the Pacific Northwest may be cited. These growers were troubled with insect pests, especially the fire worm. They applied to the United States Department of Agriculture for relief. This relief was given in the person of an excellent entomologist. The bug man did his work in 1918 and 1919. The bulletin on the subject was published in 1922. During the interim no progress or press reports were published, and the growers were without advice. The delay in getting this information resulted in considerable loss to growers and in the development of some ill feeling toward the red tape of government work. The question naturally comes out, couldn't enough information have been given the growers by way of a preliminary circular or report to have enabled them to save much of their crop? This illustration is not made in disparagement of the splendid work of the Department of Agriculture, but simply serves to show how the farmers, who back both state and federal research, may come to believe that the experimenter is a man remote from their lives and not warmly and vitally interested in their welfare.

Reports of Directors

Why is it the farmer usually consigns the station report to the waste basket? Simply because—to use a slang expression—he gets no kick out of it. Upon opening the covers he finds brief rather dry compilations of facts relating to the work of the experiment station. It is simply a boiled down narrative, not designated to give the farmer much working information, or to show how much the station means in help to the farmer.

These facts, boiled down in this way, are most certainly needed for purposes of record and are often of immense value to technical men. The farmer, however, wants something to stir his imagination and to give him a vision of big things. This can be done in a more popular fashion by stressing some of the most im-

portant pieces of work and leaving the museum of facts in the background, or entirely out of the popular form of the report.

There are signs, however, that the dry bones are being stirred by the breath of life. The Yearbook of the United States Department of Agriculture for 1921 is in a sense a report. Some of the chief problems of the country are stressed in a way to make most interesting reading. Wisconsin Station has recently been putting a resumé of its work before the people in a most readable form. In Oregon, where high taxes seem paramount in the minds of the farmers, a special effort was made in a report by the Director this year, to show the number of ways in which research work has contributed and is still contributing to the wealth produced by the farmer, and the value of the knowledge to farmers compared to the money spent in the support of the Station. Few farmers can start on that report without reading it and realizing that the money expended in the support of the station has been well spent.

Extension Helpers

Research men must not fail to realize that in the extension service they have as fine an organization for putting across the work of the station among the people of the state as could be asked for. The extension specialists, county agents, home demonstration agents, boys and girls club leaders, are the people out on the firing line who welcome all the ammunition that can be sent to the front and usually make every shot tell. A close and sympathetic acquaintance with these workers should be carefully cultivated. If special experimental work is needed for some counties, the county agent should be consulted and his opinion carefully listened to. As a rule, he is in a position to keep the experimenter from starting upon some impractical piece of work or becoming entangled in the machinations of unscrupulous persons who would like to use the work of the experimenter for personal gain. These extension people in the field can come nearer placing their finger upon problems needing investigation than almost anyone else. As a rule they are more than glad to give all credit and publicity possible to the research man when he works in their territory, or appears on their programs; on the other hand, they appreciate the recognition and courtesy among their own constituency which is their right.

There is nothing like personal contact to bring about better understandings and more closely knit sympathies. The county agents and other extension workers are, as a rule, called in annually for a conference. In most cases this conference is held at the state college and station. Such a conference gives a fine opportunity for research men to meet the field men and discuss the problems of the state with them. Out of it should come a carefully worked out program of state extension service which should embody the best thought of all parties interested.

The Personal Touch

There is a feeling among farmers in some sections that the research worker is a recluse who digs away in his laboratory, but

does not meet up with the actual problems of the farm. Experimenters have done much and are doing a great deal at present, to break down this feeling. They can best establish good relations between the farmers and themselves by getting in closer personal touch with them. When a call comes in to investigate some trouble that is bothering the farmers, such an opportunity of meeting them should be accepted, if possible. One of the finest ways of clinching the interest aroused by such investigations, is to hold a public meeting of farmers to talk the situation over and to present whatever information the experimenter may have to give. Whenever possible, the research man should speak at gatherings of farmers such as granges, picnics, county fairs, etc.

The experiment station frequently fails in the matter of acquainting the people with the work it is doing and in getting their support for continued, or increased appropriations. The work accomplished can be explained in a measure by bulletins and other reading matter, but personal acquaintance counts for more than reams of written material. In such a situation, the county agent and his organization can do very much in a quiet way to crystalize the sentiment of farmers to stand back of the station program, and the farmers in turn can bring pressure to bear upon their representatives in the state legislature to put the matter across. Unless organized efforts of this sort can be successfully made, there is little chance of the station getting all it deserves, or of the farmers obtaining the relief they really need. Another factor which may count heavily in obtaining support for the work of the station, is the interest of the alumni of the state college. Usually the experiment station and the college are located at the same place and these students have become more or less acquainted with the object of the experiment station. If the experiment station workers will take the trouble to look up the old students in the field, they can do much to fan the flame of institutional loyalty, and to get the active support of these people for any meritorious measure.

A number of stations have adopted the plan of asking farmers in the near-by counties to come to the station once a year as their guests. This usually occurs when crop growth is well advanced and comparison, therefore, can be made. Branch stations have been able to work on this plan as well as the central or home stations. To secure satisfactory attendance means good newspaper publicity coupled with the active participation of the county agents and others interested in getting the farmers together for the trip. In these days of the automobile, these trips are looked upon as profitable vacations.

Visiting the station in person is much like the inspection of an automobile factory. After a man has been conducted through the establishment where his car was made and has been shown carefully what is done and the reasons for it, he comes away with a feeling that here is a great well-organized enterprise in which he will always take a deeper interest than before. He picks up many valuable hints regarding the care of his own car. When the farmer is through his inspection of the station he feels much

like that. He has seen for himself, in a way that no amount of second-hand description could have given him, the magnitude of the agricultural problems confronting the station and the way in which they are being worked out. He goes away with a feeling of pride in the accomplishments of an enterprise he is helping to finance and, besides, he carries home many ideas of value to his own business.

The state fair and county fairs offer good opportunities for using the station label. When exhibits of station work are put on at such places, they should be carefully marked so that people may understand that they are not put on by the college, or by the extension service. In fact, it may be better, where room is available, to have the station exhibit entirely separate from the others.

The object of such an exhibit should be to stress the gravest problems of the time. Too often an exhibit is put on to cover the whole field of experimental research with the result that nothing stands out as of special importance, and the station has lost its chance to make a deep impression on the minds of the people.

Not only attractive signs, but carefully worded slogans should be worked out for such a display. As an illustration of such a slogan, the experiment station exhibit at the state fair which the writer recently attended, stressed the economic value of the work of the station by this slogan: "One Dollar Spent for Every Fifty Dollars Saved." This was supplemented by other signs showing the value of certain pieces of research work to the farmer.

SUMMARY

To sum up: Selling research to the farmer means an earnest effort upon the part of the experimenter, (1) to understand the fundamental and outstanding needs of the farmer, (2) to solve the research problem, and, then without delay, to get the results before the people in an attractive and readable shape, (3) to acquaint the people in every legitimate way with the work and purposes of the experiment station, and, (4) finally, to cooperate heartily with college and extension workers in putting across a state-wide educational program. If the research man does this, the chances are greatly in his favor that the farmer will buy all the information the experimenter has to offer and will support the work to the limit of his resources.

Catalase Activity as an Indicator of the Nutritive Condition of Fruit Tree Tissues

By A. J. HEINICKE, *Cornell University, Ithaca, N. Y.*

MANY plant and animal tissues have the ability to hasten the decomposition of hydrogen peroxide. It has been shown by Loew (10)* that this is due to the presence of an enzyme called

*See references at end of paper.

"catalase." The physiological function of this enzyme is still unknown (6, 11) although its universal occurrence in living tissue suggests that it has some significance. The literature contains records of relationships between the activity of the catalase enzyme and respiration, growth, or other vital prosesses, but the conclusions reached are by no means generally accepted. (2, 4, 5, 7, 12,

Recent studies at Cornell regarding the usefulness of catalase tests as a measure of responses of fruit trees to various treatments, indicate that the ability to decompose hydrogen peroxide is apparently associated, among other factors, with the nutritive condition of the tissue. The results also suggest that catalase activity might possibly be an expression of the carbohydrate nitrogen ratio (9). A resume of the results leading to this suggestion are given in this paper.

Methods

About one-half gram of fresh tissue (conveniently obtained in the case of leaves by a Ganong leaf cutter, or in case of the bark or fleshy tissue by means of a cork borer), is placed in a mortar along with an equal weight of calcium carbonate and some quartz sand. Enough water is added to wet the calcium carbonate. After thoroughly coating with the wet lime, the tissue is macerated for about two minutes, or until a smooth mixture is obtained. The macerated tissue is finally suspended in 10 to 100 parts of water, including that used in wetting the calcium. The more active material such as leaf tissue is diluted to the greatest degree. The preparation is transferred to a small bottle and may be kept at room temperatures for several days or weeks.

When ready to make the catalase test, one cubic centimeter of the preparation is withdrawn by means of a pipette just after stirring and thoroughly agitating the contents of the bottle. This is placed in one arm of a two-arm reaction tube, while two cubic centimeters of neutralized hydrogen peroxide are placed in the other. After connecting with a burette, the reaction tube is immersed in water kept at a temperature of 20° C. The preparation and the hydrogen peroxide are then mixed, and throughout the reaction the mixture is made to flow from one arm to the other about once a second.

The time required to release five cubic centimeters of gas, or about one-fourth of the oxygen available in the two cubic centimeters of hydrogen peroxide used, is taken as a measure of the catalase activity. The strength of the enzyme is assumed to be inversely proportional to the time required to do the work (3). For example, a preparation which releases five cubic centimeters of oxygen in 25 seconds is regarded as being approximately twice as active as a preparation that requires 50 seconds to do the same work. The values of a given preparation are always checked by repeated determinations and the values for a given treatment are established by taking several samples from similar material.

Some of the factors that influence the results of catalase tests are discussed at length in Cornell Memoir No. 62. If proper precautions are taken in the selection and subsequent treatment of

the tissue, and if all details of preparation and determination are identical, similar lots show about the same strength. The differences in catalase activity caused by the cultural treatments discussed in this paper are far greater than the experimental error involved in the selection of samples and in the determinations. Too much emphasis, however, cannot be placed upon the choice of samples that are really comparable whenever catalase tests, or any other tests, are to be used as a basis for comparative studies.

RESULTS

The data given in the table will serve as examples of the results obtained with the different treatments. While the cases cited are representative of others that show the same results, the values, of course, vary with the variety the time of year and other factors that presumably have a direct, or an indirect, influence on nutritive or the physiological condition.

Time required to release 5 cc. of oxygen from 2 cc. of 12 volume hydrogen peroxide by the catalase in 1 cc. of various apple leaf or bark preparations.

No.	Tissue	Date	*Treatment Material and Dilution*	*Time in Seconds*	*Relative Activity*
1.	Leaf	9-27-21	*Sod sandy* soil 1 yr McIntosh 1-50*	650	100
			Cultivation soil 1 yr McIntosh 1-50	280	232
2.	Leaf	9-27-21	*Sod Loam* soil 1 yr McIntosh 1-50	325	100
			Cultivation soil 1 yr McIntosh 1-50	105	310
3.	Bark	11- 3-20	*Sod Loam* soil 1 yr McIntosh 1-20	112	100
			Cultivation soil 1 yr McIntosh 1-20	54	208
4.	Leaf	11- 5-20	Sod *no* sodium nitrate 3 yr McIntosh 1-50	310	100
			Sod *3 oz.* sodium nitrate 3 yr McIntosh 1-50	115	270
			Sod *8 oz.* sodium nitrate 3 yr McIntosh 1-50	64	484
5.	Leaf	7-27-21	*Unpruned* 2 yr Wealthy trees in sod 1-50	270	100
			Pruned by thinning Wealthy trees in sod 1-50	160	169
6.	Leaf	9-22-22	*Weak* spurs 12 yr Wagener 1-50	98	100
			Strong spurs 12 yr Wagener 1-50	64	153
7.	Leaf	7-15-22	Flowers *set fruit* 12 yr Wealthy 1-50	46	100
			Flowers *removed* 12 yr Wealthy 1-50	27	170
8.	Bark	12-14-22	Flowers *set fruit* 12 yr. Wealthy 1-20	152	100
			Flowers *removed* 12 yr Wealthy 1-20	84	176
9.	Leaf	10-13-22	*Ringed* June 1922 Gravenstein tree 1-50	390	100
			Untreated June 1922 Gravenstein tree 1-50	98	400
10.	Bark	11- 1-22	*Ringed* June 1922 Gravenstein tree 1-20	125	100
			Untreated June 1922 Gravenstein tree 1-20	65	192
11.	Leaf	9- 2-22	*Exposed to light* 1 yr Delicious 1-50	59	100
			In black bags 24 hrs. 1 yr Delicious 1-50	36	164
12.	Leaf	8-15-21	*Twigs standing* in water 0 da. Wolf R. 1-100	104	100
			Twigs standing in water ¼ da. Wolf R. 1-100	65	160
			Twigs standing in water 1 da. Wolf R. 1-100	28	372
			Twigs standing in water 7 da. Wolf R. 1-100	14	743
			Twigs standing in water 14 da. Wolf R. 1-100	30	347
13.	Leaf	11-15-22	*Freezing* temperatures 1 yr Delicious 1-50	135	100
		10-30-22	*Moderate* temperatures 1 yr Delicious 1-50	47	287

*Grams fresh tissue to cc. water.

As shown by cases 1, 2 and 3, catalase in leaves and bark from

trees in cultivated land tends to be more active than that from trees growing in grass. It is well known that apple trees in sod are generally less vegetative than those under cultivation; and, furthermore, that the response of trees to cultivation and to sod varies with the soil type.

The application of sodium nitrate tends to reduce the harmful influence of grass on trees. The effects of this fertilizer are also reflected by increases in the catalase activity as indicated by case 4.

If grass tends to bring about a reduction of the available nitrogen, or water, then pruning of trees in sod by the removal of growing points and leaves, might be expected to increase the relative supply for the remaining tissue. Such a treatment as indicated by case 5 causes an increase in catalase activity.

It has been shown that relatively vigorous spurs have a better chance to develop flower buds and that flowers on such spurs are more likely to set fruit. At certain times of the year the leaves on vigorous spurs (case 6) likewise show greater catalase activity.

Cases Number 7 and 8 indicate that the removal of flowers in spring before they expand, results in an increase in catalase activity as compared with the tissue from portions of the same tree where the flowers are allowed to open and set fruit. The last stages in the development of flowers and possibly the early stages in the formation of fruit, cause a reduction in vegetative activity as shown by smaller leaves and shorter and more slender shoots, as well as by the production of fewer flowers buds.

Ringing during the growing season is known to bring about an accumulation of carbohydrates above the ring, and possibly also to prevent further increases in the nitrogen content of the tissue. The catalase in the bark as well as in the leaf, is less active as a result of the treatment as shown by cases 9 and 10. The trees used in this experiment received heavy applications of nitrate a month before ringing. The reduction in catalase activity is more marked in trees of moderate vigor at the time of ringing.

The ability of tissue to decompose hydrogen peroxide is easily influenced by exclusion of light. As indicated by case 11, leaves inclosed in black paper for 24 hours showed greater catalase activity than those normally exposed. Tissue from the former leaves showed the same activity as the latter at the beginning of the experiment. Among other things, carbohydrate assimilation is impossible in the dark, acidity is increased and also the proportion of nitrogen probably becomes greater.

A rather marked increase in catalase activity from day to day is shown in leaf tissue on excised twigs with their cut ends in water (case 12). This is probably associated with translocation of carbohydrates from the leaves together with unfavorable conditions for further assimilation. Leaves from which all chlorophyll has disappeared and which abscise while still turgid, show very little catalase.

When exposed to temperature near the freezing point, the partially developed leaves on the vigorous shoots of many varieties of apples assume a reddish tint, and they show a tendency

to become more or less leathry in texture. This is probably associated with an accumulation of carbohydrate material. With the approach of freezing weather the catalase activity of leaf tissue falls off rapidly as shown by case 13. Tissue killed by cold has little if any ability to hasten the decomposition of hydrogen peroxide.

Discussion

Attention should be called to the fact that many of the catalase preparation of apple leaves are more active than any other preparations of plant or animal tissue reported in the literature. In the dilutions of 1 to 100, a sample of one cubic centimeter contains about 10 milligrams of fresh tissue. In some cases this amount destroys hydrogen peroxide several times more rapidly than an equal weight of finely powdered manganese dioxide.

The cases presented in the table indicate that many cultural treatments and conditions have a marked effect on catalase. In general, conditions or treatments which seem to favor vegetative activity tend to increase the catalytic power of the tissue with reference to hydrogen peroxide, while conditions which are less favorable for growth tend to decrease catalase activity. It is reasonable to assume that nitrogen is present in relatively large amounts in tissues showing strong vegetative tendencies, while the proportion of carbahydrates increases as the vegetative tendencies become less pronounced. A relatively low catalase activity seems to accompany a nutritive condition in which the proportion of nitrogen to carbohydrates is very low. The higher the nitrogen content, or the higher the proportion of nitrogen to carbohydrates, apparently the greater the catalase activity.

Chemical analyses in support of this hypothesis have not been made in connection with the experiments given in the table. However, Professor E. C. Auchter, who has been doing graduate work at Cornell during the past year, has made catalase tests of leaf tissue which was subsequently analyzed for nitrogen. I am indebted to Professor Auchter for the opportunity to look over his results. A cursory examination of his data, which are not yet in final form, reveals a rather striking relationship between catalase activity and nitrogen content in case of the peach. The evidence in case of the apple and oak, where the nitrogen content of leaves has been less markedly influenced by the experimntal treatment, likewise shows that catalase activity is stimulated by increases in nitrogen, but it also points to the depressing effects of carbohydrates. Further work is needed to establish consistent relationships between the variations of the CN ratio and the ability of tissue to destroy hydrogen peroxide.

Concluding Remarks

The catalase test promises to be especially well adapted for studies involving frequent determinations of the same material. Very little tissue is needed (less than 0.25 gram will give dependable results) and the determinations are easily and quickly made. Numerous samples can be taken to establish the limits of normal

variation without necessitating the destruction or serious injury of the experimental subject. The catalse activity of a given lot of leaves, for example, can be established before and after treatment and changes can be checked with those naturally occurring in untreated leaves previously subjected to the test.

It is probably too much to expect catalase activity to serve as an indicator of general metabolism of plant tissue. The catalase determination, however, seems to have possibilities of application in studying general nutritive changes which are brought about by cultural or experimental treatments, as well as those which are normally going on in the tissue from day to day, or even from hour to hour. It is not unlikely that such studies will help in revealing the fundamental physiological significance of the enzyme.

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Possibilities of Nursery Tree Certification

By J. K. Shaw, *Massachusetts Agricultural College, Amherst, Mass.*

ONE of the difficulties encountered by the fruit grower, is that of finding that many of his trees prove untrue to name. There seems to be no easy way of finding out what proportion of trees prove untrue, but it is the judgment of the speaker that in southern New England it is somewhere around 10 per cent. Probably in recent years there have been around 100,000 apple trees planted annually in Massachusetts. If 10 per cent of these are untrue to name, it indicates a serious loss to Massachusetts fruit growers. Fruit growers have protested often to the nurserymen and the national organization of the nurserymen has made efforts to correct the difficulty, or at least such of it as may be due to intentional substitutions, or gross carelessness on the part of the nurseryman. Probably it can be said with truth that these efforts have met with little success for various reasons and that the problem of the misnamed tree has not been solved.

In June, 1921, a meeting was called by Director Haskell of the Massachusetts Experiment Station, to consider this and related questions. There were present representatives of the State Department of Agriculture, the Massachusetts Fruit Growers Association, and of the Massachusetts Agricultural College and Station. At this meeting a plan of nursery tree certification was discussed and steps taken to put it in operation. The Massachusetts Fruit Growers Association at a later meeting voted to assume the sponsorship of the plan and it was carried out in the seasons of 1921 and 1922.

This plan rests on the proposition that it is possible to tell if the varieties in the nurseryman's plantation are correctly named or not. The means of identification have been partially dealt with in Bulletin 208 of the Massachusetts Experiment Station, and need not be discussed at length here. Thus far only apples have been dealt with and only two year trees certified. I can assure you that the correctness of the nurseryman's name can be determined by an inspection of the growing trees in the summer or fall with a reasonable degree of certainty.

The plan as carried out the past two years is as follows: The Massachusetts Fruit Growers Association offers certification of 12 leading varieties of apples to any nursery in the state, or of any trees to be purchased by growers or dealers in the state. On application to the Association, a representative of the Experiment Station examines the trees, and if satisfied that they are true to name, a hole is drilled in a branch of the tree and an ordinary lead seal is inserted and sealed with a hand seal press. The seal bears the letters "M. F. G. A. 1922" (or any year in which the work is done), and on the reverse, "Certified to be Baldwin," or any other of the 12 varieties. The cost of the work is paid by the applicant and has amounted to from two to three cents per tree.

In 1921, about 3,000 trees were examined of which a little less

than 10 per cent were found misnamed and refused certification. In 1922, a little less than 10,000 trees were examined and several hundred misnamed trees were eliminated from the nursery trade.

Of course, so long as this plan is limited to Massachusetts, or to any one state, it does not solve the problem. The nursery trade is an interstate business. At the present time, negotiations are pending for the certification next year of many thousands of trees in a nursery in another state, and other nurseries are inquiring about the scheme. The Massachusetts Fruit Growers Association seems to be willing to sponsor this extension of the work as a temporary arrangement, pending the time it may be taken over by a national organization. It would seem that there are three organizations that might be considered in this connection. These are the American Association of Nurserymen, the American Pomological Society, and the American Society for Horticultural Science. It would seem that one of these should become responsible for the employment of disinterested experts, and the supervision of the work. The first named may be objected to on the ground that it is an organization of the men whose work is to be passed upon. This may not be a vital objection, but it might be more desirable to place the work under a disinterested supervision. It seems to the speaker that this is a matter which this society should interest itself in, and express an opinion as to the oversight of this work in case it develops to larger usefulness.

An Experiment in Ringing Apple Trees

By J. K. Shaw, *Massachusetts Agricultural College, Amherst, Mass.*

THE experiment here reported was a minor one, and was never dignified to the extent of being placed on a project basis as is all the research work of the Department. The trees were planted in 1911, rows A to D being Wealthy, E to H Oldenburg and I to L Wagener. There were 21 trees in each row and they were planted 10 feet apart each way. The orchard thus consisted of early bearing varieties closely planted to see if they would bear commercially profitable crops before the orchard became excessively thick. In 1918, the trees being seven years old, it had not borne satisfactory crops and half of the trees were ringed. The ringed rows ran across the varieties, each row consisting of four trees each of Wealthy, Oldenburg and Wagener. The dates of ringing were as follows; rows 2 and 12, May 31; rows 4 and 14, June 15; rows 6 and 16, July 1; rows 8 and 18, July 15; and rows 10 and 20, on August 1. A ring of bark about three-fourths of an inch wide reaching entirely around the trunk just below the main branches was removed and a band of waxed paper about 2 inches wide wrapped around and tied above and below the cut with raffia. The wounds healed well except on some of the trees ringed August 1, and on a few of those ringed July 15. It was clear that the earlier the ringing was done the better the healing, although there was little difference between the first three lots.

No significant differences were noted during the season of 1918 except that the fruit on the ringed Oldenburgs seemed to mature slightly earlier than that on the unringed trees.

Estimates on the size of the crop on each tree were taken at the time of ringing and again a year later. These are shown in table 1. This shows that it was the early ringing that was effective in causing fruit-bud formation.

TABLE I.

Yield of Ringed Trees

Row	Date of ringing	1918	1919	1918	1919	1918	1919	1918	1919
		Wealthy							
		Tree 1		Tree 2		Tree 3		Tree 4	
2	May 31............	O	H	H	O	L	H	M	H
12	May 31............	H	L	H	L	H	M	H	L
4	June 15............	M	L	H	L	O	H	H	L
14	June 15............	M	L	L	H	M	M	H	O
6	July 1............	H	L	L	O	L	M	L	M
16	July 1............	M	O	L	M	L	M	M	O
8	July 15............	H	O	M	L	M	L	M	L
18	July 15............	L	L	M	O	O	L	L	M
10	Aug. 1............	L	L	L	M	M	L	M	L
20	Aug. 1............	L	M	M	L	M	M	L	H
		Oldenburg							
2	May 31............	H	H	L	H	M	H	M	H
12	May 31............	L	M	H	M	M	H	H	M
4	June 15............	L	M	M	M	M	M	O	L
14	June 15............	L	H	L	M	L	M	L	M
6	July 1............	L	M	L	L	L	L	L	L
16	July 1............	O	L			O	O	L	M
8	July 15............	L	L	L	M	M	L	L	M
18	July 15............	M	M	L	M	M	O	L	M
10	Aug. 1............	M	L	M	O	M	O	L	L
20	Aug. 1............	L	L	L	L	M	O	L	L
		Wagener							
2	May 31............	L	H	H	O	L	H	M	H
12	May 31............	M	H	O	H	L	H	O	H
4	June 15............	O	H	O	H	O	H	O	H
14	June 15............	O	M	O	H	O	H	O	H
6	July 1............	O	M	O	M	O	M	O	H
16	July 1............	O	L	O	H	O	M	O	M
8	July 15............	L	L	L	M	L	M	O	M
18	July 15............	O	L	O	L	O	M	O	M
10	Aug. 1............	O	M	O	M	O	M	O	M
20	Aug. 1............	O	L	O	L	O	L	O	M

O=No fruit M=Medium crop
L=Light crop H=Heavy crop

There is little if any difference between those of May 31 and June 15, but they form a sharp contrast with the last two ringings which seem to have had no influence in promoting the formation of fruit buds. The ringing of July 1 seems to have had a slight influence.

The table shows also that ringing was ineffective on trees carrying a heavy crop. Trees carrying a light crop, or no fruit, responded in every case to the earlier ringing with an increased crop the next year.

There seems to have been some differences with varieties, Wagener having responded better than the other two varieties. On previous years Wageners had borne less fruits than the other varieties and were growing more vigorously. Of course the heavier crops in 1919 are due largely to the fact that few Wagener trees bore crops in 1918, but it seems fair to conclude that there is some response beyond this.

The crops on the check trees in 1918 were comparable to those of the ringed trees. Unfortunately, complete records of the crops of those check trees in 1919 are not available. Such as we have show the crop to vary from none to moderate. Not one of the 36 trees of all three varieties of which we have records had a heavy crop in 1919. On most of them the crop was recorded as light.

The total yield in 1919 of the 22 ringed Oldenburgs was 13½ bushels as against 6¾ bushels for the 22 check trees. Reference to table 1 will indicate that the larger part of this excess from the ringed trees was from those ringed May 31 and June 15, for six of these had heavy crops as against none of an equal number of late ringed Oldenburgs.

Of the crop of 1920, the second year after girdling, only the total yields of the girdled and ungirdled Wealthy and Oldenburg trees are available. These records show that the ringed Wealthys yielded 15 bushels as compared with 6½ bushels for those not ringed. The Oldenburgs gave 18¾ bushels from the ringed trees and 27¾ bushels from the unringed trees. The year 1920 should have been the off year for the ringed trees yet the ringed Wealthys yielded more than those not ringed.

In the spring of 1921, alternate trees in every row were removed. This of course included one-half of both ringed and check trees. At the same time the orchard was laid out for a fertilizer experiment, but it happens that the plots are arranged so that the ringed trees are equally distributed over the fertilizer plots, and it is reasonable to suppose that this new experiment has in no way affected the average results from the ringing experiment.

The yields for 1921 and 1922 for the remaining trees, are shown in Table II. These figures must be considered with reservations, for there was a freeze in the spring of 1921 which was normally the on-year for the ringed trees, and that interfered to an unknown degree with the yield. The Wealthy suffered less than many others and the early ringed trees of this variety have outyielded their checks in both years. Possibly the inferiority of the

early ringed Oldenburg and Wagener trees may be due to frost injury.

TABLE II.

Average Yields per Tree, Pounds.

		Early ringed	Check	Late ringed	Check
Wealthy	1921............	45	11	11	25
Wealthy	1922............	167	164	149	195
Wealthy	Total...........	212	175	160	220
Oldenburg	1921............	31	8	13	13
Oldenburg	1922............	53	124	107	121
Oldenburg	Total...........	84	132	120	134
Wagener	1921............	69	17	36	18
Wagener	1922............	54	144	49	163
Wagener	Total...........	123	161	85	171

TABLE III.

Average Trunk Diameter, Millimeters

		Early ringed	Check	Late ringed	Check
Wealthy	1921............	97	101	97	103
Wealthy	1922............	99	104	98	107
Wealthy	1923............	104	108	102	112
Increase	2 Years..........	7	7	5	9
Oldenburg	1921............	92	90	97	90
Oldenburg	1922............	95	98	100	95
Oldenburg	1923............	104	105	107	103
Increase	2 Years..........	12	15	10	13
Wagener	1921............	112	107	104	111
Wagener	1922............	115	113	105	116
Wagener	1923............	129	122	113	125
Increase	2 Years..........	17	15	9	14

It seems reasonable to conclude that the late ringing has produced a check in the yield which still persists 4 years after the work was done.

Unfortunately, no measures of growth were made before nor immediately after the ringing, but trunk diameters were taken in the spring of 1921 and the following year. These are averaged in Table III. These show a decided check in growth by the late ringing, but with the early ringed trees the figures do not show clearly any check. Observation of the orchard would lead anyone to conclude that most of the late ringed trees are smaller and less vigorous than either the early ringed or check trees.

The scar caused by the ringing is of course still plainly visable. It would be interesting to know if this scar inhibits the passage upword or downward of carbohydrates or other nutrient matter.

Conclusions

1. Ringing vigorous unfruitful trees during or immediately following the first burst of growth will stimulate fruit-bud formation. Ringing fruitful trees at the same time does not stimulate fruit-bud formation, but no marked ill results follow.

2. Ringing similar trees in midsummer not only fails to stimulate fruit-bud formation, but may seriously weaken the tree and inhibit both growth and fruit production.

3. Where marked stimulation of fruit-bud formation follows ringing, it establishes the on-year of blooming which continues in alternate years until interfered with by some environmental influence.

Experiments with Sulfur Spray Mixtures

By A. J. Farley, *Experiment Station, New Brunswick, N. J.*

MIXTURES in which sulfur is the active ingredient are now recognized in most districts as the best summer fungicide for use on the pomaceous and drupaceous fruits. The copper sprays, such as bordeaux mixture, in general use prior to 1910, have been almost entirely discarded in many sections, because of the great danger of serious injury to fruit and foliage. Some of the sulfur mixtures, on the other hand, although safer than those containing copper, often cause considerable injury particularly when applied in hot weather with the modern spray gun, under high pressure. Concentrated lime-sulfur for example, although cheap, effective, and convenient, cannot be used at all as a summer spray on peaches, because of the severe injury it is likely to cause, while in some parts of the country it must be used with great caution on apples and pears. Self-boiled lime-sulfur, recognized since 1908 as the standard summer fungicide for peaches and other stone fruits, although comparatively cheap and effective is difficult and troublesome to prepare and apply. Furthermore, the strength of different lots of self-boiled mixture varies with the kind and quality of the lime, the amount of slaking that takes place, and the temperature of the water used. The danger of injury involved in connection with the use of concentrated lime-sulfur and the inconvenience of self-boiled, has brought both mixtures into disfavor in many fruit growing sections. Many attempts have been made to develop a mixture that would have a higher degree of safety than concentrated lime-sulfur, more convenient than self-boiled, and at the same time be effective as a summer fungicide. For many years it was thought that a sulfur mixture to be effective must contain a certain amount of soluble sulfur in the form of polysulfides. The successful use of sulfur dusts on peaches, and to a less extent on apples, shows that mechanical mixture of finely divided sulfur and lime may be effective. The chief weakness of the sulfur dusts now available for apples is their inability to stick to the smooth fruit and foliage, during rainy weather, thus giving protection for a shorter period than sulfur mixtures applied in liquid form.

Very satisfactory results have been secured in several states with mechanical mixtures of finely divided sulfur and lime applied in liquid form. In 1917, the New Jersey Experiment Station

developed and recommended the New Jersey Sulfur Glue Mixture as a substitute for Self-Boiled Lime-Sulfur. This mixture is prepared according to the following formula:

8 pounds sulfur (superfine preferred)
4 pounds hydrated lime
1½ ounces of ground glue dissolved in 3 gallons of water.
Dilute with water to make 50 gallons,

The satisfactory results secured with this mixture during the last five years show that a good mechanical mixture of sulfur and lime applied as a wet spray is an effective summer fungicide. The chief difficulty in the preparation of such a mixture is to wet the sulfur and bring it into suspension in water. The New Jersey Sulfur Glue Mixture overcomes this difficulty by first treating the sulfur with a glue solution.

Development of Dry Mix Sulfur Lime

The idea was conceived early in the spring of 1922 that dry calcium caseinate might be substituted for the glue and thus make a dry mixture of sulfur and lime that would mix readily with water.

Formula

The same amounts of sulfur and lime are used as in the New Jersey Sulfur Glue Mixture, the only change in formula being the use of calcium caseinate in place of ground glue. The following ingredients are recommended for making 50 gallons of spray mixture:

8 pounds superfine sulfur.
4 pounds hydrated lime.
8 ounces calcium caseinate.

The above amounts may be proportionally increased or decreased to meet the requirements of any spray tank.

Materials

Sulfur—It is recommended that a high grade of commercial sulfur flour, or very fine dusting sulfur be used. Common commercial ground sulfur may give satisfactory results in some cases, but the superfine material is better, particularly when conditions favor the development of fungous diseases.

Lime—Fresh, hydrated lime of a high grade, free from grit and dirt should always be used.

Calcium Caseinate—The powdered form of calcium caseinate now on the market under a number of trade names is recommended.

Preparation

Weight out the proper amounts of sulfur, hydrated lime, and calcium caseinate. Sift the sulfur through a screen to eliminate all lumps. Mix the proper amounts of sulfur, lime and calcium caseinate together dry, being careful to secure a uniform mixture. The dry mixture thus obtained constitutes what the New Jersey Experiment Station knows as Dry Mix Sulfur Lime. This mixture

may be stored in bags or barrels for an indefinite period provided it is kept in a dry place.

Dilution of Dry Mix Sulfur Lime

Dry Mix Sulfur Lime, made in accordance with the New Jersey Experiment Station formula, should be used at the rate of 12½ pounds to 50 gallons of water. Three methods of diluting Dry Mix Sulfur with water are recommended.

Method No. 1—Place the proper amount of material in a barrel, or other container which will hold water. Add water slowly, stirring the mixture until the grains of sulfur are wet, and a thin solution is obtained that will pass readily through a strainer into the spray tank. Strain the material into the spray tank after same is at least one-half full of water. This method is recommended particularly for use with hand outfits, or where it is not convenient to have the agitator running when the tank is being filled.

Method No. 2—Wash the proper amount of Dry Mix Sulfur Lime through the strainer into the spray tank with the agitator running. This method can only be used to advantage where a strong flow of water from an overhead pipe or hose is available. The strainer used should not have more than 12 to 14 meshes to the inch.

Method No. 3—Dump the proper amount of Dry Mix directly into the spray tank after same is at least one-half full of water. As in method No. 2 the agitator should be running when the dry material is added to insure a thorough mixture with a minimum amount of settling.

Orchard Tests

The value and effectiveness of Dry Mix Sulfur Lime as compared to other mixtures in general use as summer fungicides, was tested during the past summer by a number of orchard tests, including three on peach and three on apple. The peach spraying experiments included comparisons between dry mix sulfur lime, self-boiled lime-sulfur, Atomic Sulphur, New Jersey Sulfur-Glue mixture and sulfur lime dusts, together with a study of the effectiveness of Dry Mix Sulfur Lime mixtures having a relative low sulfur content. This discussion will be limited to the results of one experiment conducted in a peach orchard where scab was quite serious. This experiment was conducted in an 8-year-old orchard and each treatment included Carman, Lola, Hiley, Belle of Georgia, Elberta, and Iron Mountain. Starting with the shuck fall on May 8, seven applications were made to all varieties except Carman and Lola, which had six. Five spraying treatments and one dusting treatment were made as follows:

Block 1—Atomic Sulphur, 5 pounds to 50 gallons of water.
Block 2—New Jersey Sulfur Glue Mixture.
Block 3—Dry Mix Sulfur Lime (Standard).
Block 4—Dry Mix Sulfur Lime (Special).
Sulfur 2 pounds, Lime 4 pounds, Calcium Caseinat 2 ounces. Water to make 50 gallons.

Block 5—Self-Boiled Lime-Sulfur 8-8-50.
Block 6—Check (No summer spray).
Block 7—Niagara 80-10-10 dust mixture in the first two applications, and Niagara 80-20 dust in all later applications.

The average amount of spray material used per tree was 1 gallon, and the average amount of dust per tree was one-half pound. Each block included five rows across the varieties with the exception of the check which consisted of only one row. The number of disease free, slightly scabby, badly scabby and brown rot affected peaches, was recorded based upon the entire crop of fruit picked from at least three and in some cases four trees of each variety in each block. A peach was not considered free from disease unless it was absolutely free from scab and brown rot. The slightly scabby class included fruit with from one to ten small or inconspicuous spots of scab, or not enough to lower its market value. All fruits in the badly scabby class had enough scab to lower the market value, and in many cases make it worthless for market. The following table is a summary based upon the results secured with all the varieties.

Treatment	Total Fruits	Per cent Free from Disease	Per cent Slightly Scabby	Per cent Badly Scabby	Per cent Brown Rot
Check	14738	48.6	34.7	14.8	1.9
Atomic Sulphur	14155	55.9	28.5	14.3	1.3
Dry-Mix Special, 2-4-50	18294	69.1	20.3	9.5	1.1
Self-Boiled Lime-Sulfur	16773	89.5	7.3	2.4	.8
New Jersey Sulfur Glue	12938	93.4	4.4	1.4	.8
Sulfur Dust	17145	95.1	3.7	.4	.8
Dry Mix Standard, 8-4-50	11927	96.1	2.8	.5	.6

The data in Table I indicate that Dry Mix Sulfur Lime with an average for all varieties of 96.1 per cent fruit free from disease as compared to 89.5 per cent in the block sprayed with Self-Boiled Lime-Sulfur, and 48.6 per cent in the check block is a very effective summer fungicide for peaches. The New Jersey Sulfur Glue mixture with an average of 93.4 per cent clean fruit was also very effective. On the other hand, Atomis Sulphur with only 55.9 per cent and the Dry Mix Sulfur Lime Special No. 1 with 69.1 per cent fruit free from disease were comparatively ineffective. The exceptionally high percentage of clean fruit secured with Dry Mix Sulfur Lime and the New Jersey Sulfur Glue mixture in an orchard where scab was very prevalent, and during a season that was favorable to its development, indicates that both are dependable summer fungicides for peaches and fully as effective as the standard Self-Boiled Lime-Sulfur. The poor control secured with Atomic Sulphur and the Dry Mix Sulfur Lime Special, both mixtures having a low sulfur content, emphasizes the fact that it is not safe to depend upon such mixtures as summer fungicides for peaches, particularly in orchards where fungous diseases such as scab and brown rot are likely to be prevalent. There has been a tendency for several years on the part of manufacturers as well as fruit

growers to reduce the sulfur content of summer fungicides in order to lower their cost. That such a practice may result in a heavy reduction of clean fruit is shown in a very striking manner in the results of this experiment. In orchards where scab and brown rot are not serious, very satisfactory control may be obtained with a fungiside having a low sulfur content, but results under such conditions do not determine the real value of a spray mixture and are often misleading.

Results With Sulfer Dusts

Dusting with 95.1 per cent of fruit free from disease proved to be a very effective fungicide in this experiment, but on the other hand caused very severe defoliation. Over one-third of the leaves dropped from the dusted trees before the middle of August, and by September 15, the same trees had lost at least two-thirds of their leaves. The exact cause of this serious defoliation has not been definitely determined, but it was probably due to liberal applications of a dust mixture containing insufficient lime in proportion to the arsenate of lead and sulfur content. The severe injury resulting from the use of dust in this experiment substantiates the conclusions drawn from dusting experiments conducted by the New Jersey Experiment Station in the past, to the effect that any dust mixture containing less than 20 per cent of lime is not safe for use on peach foliage.

Experiment With Apples

The apple spraying experiments included comparisons between dry mix sulfur lime cannot be determined from the results of these summer strength concentrated lime-sulfur. The exact value of dry mix sulfur lime cannot be determined from the results of these tests, owing to the absence of scab and other serious fungus diseases from all of the orchards in which the experiments were conducted. However, all the data secured, togther with observations made during the season, indicate that it is just as effective as self-boiled lime-sulfur on apples and much less dangerous to use than summer strength concentrated lime-sulfur. The New Jersey Experiment Station is now recommending Dry Mix Sulfur Lime to fruit growers in New Jersey as a substitute for self-boiled lime-sulfur as a summer fungicide for all kinds of tree fruits, and beginning with the petal fall applications it is recommended as a substitute for summer strength concentrated lime-sulfur on apples, except when such diseases as blotch, bitter rot and cedar rust are serious.

Changes in the Respiration Rate of Ripening Apples

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THE work of Gore (1) with apples and other fruits established that the rate of carbon dioxide evolution of fruits increased with temperature according to the van't Hoff rule, i. e., the rate doubled, or trebled, with each increase in temperature of 10 degrees c.

The work on which this paper is based was done at the Marble Laboratory, Canton, Pennsylvania, during the Fall of 1922. It consists chiefly of determinations of the rate of carbon dioxide evolution at 68.5° F. of Wealthy, Wagener and Baldwin, at successive intervals through the ripening season, and under various treatments and conditions. A few experiments were carried on at temperatures other than 68.5° F. In addition, some determinations of hardness, and of percentage of moisture and of acid, were made on Wagener apples. A few respiration experiments were carried on with Ben Davis and Northern Spy.

The fruit used in the experiments came from 12 year old trees bearing their first real crop. The Wealthy, Wagener, and Ben Davis, were in appearance typical of their varieties. The Baldwin and Northern Spy were abnormally large.

At the beginning of the work, a number of trees were labelled and successive pickings made from them through the season. Each picking was made by the writer and was as close as possible to a representative sample of the crop. Only fruit of average size, with whole skins, and free from all defects, was used.

Pickings of Wealthy were made at 7 successive intervals from August 14 to September 18. The commercial picking of that variety was done from September 4 to 9. At the time of the first picking, the fruit had not reached normal size nor attained good color. However, the period from August 24, when the second picking was made, to September 12, when the next to the last sample was taken, may be said to constitute the possible commercial picking season. By the time the last lot was picked the fruit was dropping badly.

Lots of Wagener were picked at 11 different times, from August 14 to October 24. The possible commercial season extended from September 25 to October 12 or possibly 16. The commercial picking was done from October 2 to 9. The optimum picking time for most of the trees in the experimental plot seemed to be about October 8. Tree 1 matured later than the others. Severely cold weather from October 17 to 22 affected Wagener picked after that date, as well as the Baldwins and Ben Davis. During this time the temperature went down to 20° F. on two different nights. There was no visible injury to fruit that was hanging on the trees during this cold period, but the subsequent respiration rate was affected.

The Baldwins were sampled 7 times, from August 24 to October 24. The possible commercial picking season extended from September 26 to October 16. The optimum picking time for Baldwin, Northern Spy and Ben Davis seemed to be about October 16.

The mean weekly outdoor temperatures and the weekly minimum temperatures during most of the period covered by the pickings are given in Table IV.

The method for determining the rate of carbon-dioxide evolution was essentially the same as that used by Gore (1). Twenty to 30 apples weighing from three to four kilograms, were used in each experiment. The results are expressed in milligrams of carbon-dioxide per kilogram hour.

RESPIRATION AT 68.5° F. OF APPLES IMMEDIATELY AFTER PICKING

Athough no attempt was made to determine whether or not the respiration rate changed with the actual separation of the fruit from the tree, a large number of determinations were made of the rate of carbon dioxide evolution from the fruit during the period just subsequent to picking. The procedure was as follows: Pickings were made at successive intervals through the season, and the fruit immediately placed in the 68.5° F. room. It was allowed one day in all cases to come to the temperature of the room, then placed in a desiccator and the rate of carbon dioxide evolution determined for a period of from 10 days to a month. The first run was usually shorter than later ones, from 1½ to 3 days being allowed and especial care being taken to run the air through the apparatus at a good speed, so that a good measure of the initial rate could be obtained. The results are presented in Table I. The numbers above the figures giving the rate of carbon dioxide evolution, indicate the duration in days of the run for which the rate is given.

After a certain period off the tree, a marked increase in respiration rate occurred in all 5 varieties studied.*

*Similar results were previously obtained by Mr. J. R. Magness, of the United States Department of Agriculture, on Bartlett Pears. The writer examined these unpublished data at the beginning of the present work and wishes to express his appreciation of the aid received from Mr. Magness in the work.

TABLE I.

Respiration rate of apples at 68.5° F. at successive intervals through the ripening season, 1922. Duration of runs in days indicated above rate figures.

Experiment	Date picked	Tree No.	Run No. 1	Run No. 2	Run No. 3	Run No. 4	Run No. 5	Run No. 6	Run No. 7	Run No. 8
			Milligrams of CO_2 per kilogram of fruit per hour							
			Wealthy							
3	Aug. 14.....	1	2 14.73	3 27.00	3 29.90	4 36.05	.....	.....	.....	.....
5	Aug. 24.....	2	2 19.05	3 26.61	3 31.76	2 32.05	3 28.51	3 31.12	.....	.....
6	Aug. 24.....	2	2 17.02	3 29.62	3 27.86	2 34.02	3 30.29	3 30.88	.....	.....
7	Aug. 30.....	1	2 23.24	3 31.60	3 33.80	3 31.58	.....	.....	.....	.....
11	Sept. 5.....	1	2 21.58	3 33.57	3 31.70	4 30.04	2 32.80	3 29.20	3 28.16	.....
12	Sept. 5.....	2	2 25.12	3 29.60	3 30.09	4 29.26	.....	.....	.....	.....
13	Sept. 7.....	2	2 21.04	3 26.61	3 25.80	3 30.90	.....	.....	.....	.....
15	Sept. 12.....	1	2 22.34	3 28.20	3 31.90	3 23.65	2 23.52	.....	.....	.....
18	Sept. 18.....	1 & 2	2 27.90	3 30.80	3 33.05	3 29.76	.....	.....	.....	.....
			Wagener							
4	Aug. 14.....	1	3 12.90	3 13.00	3 10.97	4 10.78	.....	.....	.....	.....
6	Sept. 2.....	2	2 10.41	3 12.97	4 9.73	3 10.78	4 13.44	3 18.55	3 17.95	3 14.92
9	Sept. 11.....	2	3 10.68	3 11.72	3 11.50	3 14.02	3 16.34	.....	.....	.....
10	Sept. 11.....	3	3 10.03	3 10.52	3 11.55	3 15.40	3 17.45	3 19.00	4 15.57	4 15.92
13	Sept. 18.....	3	3 10.11	4 10.80	3 11.26	4 16.49	4 18.04	.....	.....	.....
17	Sept. 25.....	1	3 10.33	3 10.12	4 14.04	4 20.48	3 15.61	.....	.....	.....
18	Sept. 25.....	4	3 11.55	4 15.08	4 22.90	4 20.64	4 18.26	4 15.95	4 18.30	.....
23	Sept. 30.....	1	4 11.13	4 14.34	4 17.00	3 17.45	.....	.....	.....	.....
25	Oct. 4.....	4	3 13.88	3 15.62	4 21.07	4 18.92	4 17.80	3 15.93	.....	.....
26	Oct. 4.....	3	3 13.13	4 14.63	3 18.92	4 18.56	4 18.56	.....	.....	.....
27	Oct. 8.....	*	1½ 11.90	3 16.14	4 16.06	4 18.00	4 13.81	3 14.33	.....	.....
28	Oct. 8.....	*	1½ 11.44	3 12.48	4 18.78	4 17.26	4 17.71	3 17.77	3 17.77	.....
29	Oct. 8.....	1	3 10.00	3 15.86	4 14.52	4 17.28	3 14.78	4 15.19	.....	.....
34	Oct. 12.....	2	2 13.49	3 21.02	4 20.82	4 17.96	.....	.....	.....	.....
36	Oct. 16.....	3	2 12.74	lost						
37	Oct. 24.....	1	2 22.98	3 24.88	3 30.24	3 24.60	3 28.52	.....	.....	.....
38	Oct. 24.....	1	2 14.88	3 24.91	3 21.80	3 18.66	3 24.30	5 20.40	.....	.....

Experiment	Date picked	Tree No.	Run No. 1	Run No. 2	Run No. 3	Run No. 4	Run No. 5	Run No. 6	Run No. 7	Run No. 8
			Milligrams of CO_2 per kilogram of fruit per hour							
					Baldwin					
1	Aug. 24.....	1	3 11.68	4 12.51	4 11.84	4 16.78	3 21.22	3 20.20	.....	.....
4	Sept. 4.....	1	4 11.78	3 11.00	3 19.02	3 20.46	.....	.....	.....	.....
7	Sept. 14.....	1	3 11.38	3 16 66	4 19.01	3 21.96	.....	.....	.....	.....
8	Sept. 26.....	1	3 18.23	4 22.60	4 23.98	3 23.36	.....	.....	.....	.....
9	Oct. 10.....	1	2 14.16	3 16.46	3 30.09	4 20.76	3 24.37	3 24.36	.....	.....
10	Oct. 16.....	1	2 16.66	4 24.10	3 28.32	3 29.63	3 27.76	.....	.....	.....
11	Oct. 24.....	1	2 25.28	3 33.00	3 25.40	3 33.00	3 33.32	.....	.....	.....
					Northern Spy					
1	Sept. 26.....	1	3 18.09	4 22.17	4 25.90	3 25.82	.....	.....	.....	.....
2	Oct. 10.....	2	2 22.00	3 24.45	3 29.75	4 25.02	3 25.00	4 25.60	.....	.....
					Ben Davis					
1	Sept. 26.....	1	3 13.59	4 14.16	4 20.78	3 19.57	.....	.....	.....	.....
2	Oct. 10.....	1	3 12.66	4 15.68	5 21.35	3 21.83	4 21.72	.....	.....	.....
3	Oct. 23.....	2	3 25.21	3 24.27	3 28.02	3 21.48	3 22.10	.....	.....	.....

*Composite sample

In all the samples of Wealthy, and in the lots of the other four varieties picked during the commercial picking season, this increase seemed to begin immediately after picking. Immaturely picked samples of Baldwin and Wagener held the low initial rate for some time, but the more mature the apples, the more quickly the increase in rate occurred. In the case of Wagener, there was a decrease in rate after 3 or 4 weeks at 68.5° F.

Examination of the results for the first runs of the experiments, given in the first column of Table I, shows that there was a general increase in initial rate as the season went on. During the possible commercial picking season for each variety, the initial rate of successive samples did not increase much. The last picked samples of all varieties except Northern Spy showed a marked increase over previous picks. Overmaturity, and a partial formation of the abscission layer cutting the fruit off from contact with the tree, may be the factor involved here, especially with Wealthy. The Wagener, Baldwin and Ben Davis apples, however, had not become overmature in appearance, nor were they dropping badly, when the last pick was made. It seems more likely that a cold period just before the last picking (See Table I and IV), may have been involved in the increased respiration rate. In the case of the last pick of Wealthy only the initial rate increased; the last picked samples of Wagener, Baldwin and Ben Davis respired at an ab-

normally high rate throughout the experiments. There was no killing of tissue as a result of the low temperatures, but Baldwin and Ben Davis apples exposed to 20° F. on the trees were observed to become mealy very quickly when held at 68.5° F. No such observations were made in the case of Wagener. It may be that incipient freezing injury was the cause of the increased respiratory activity of the last picked samples of Wagener, Baldwin and Ben Davis.

Effect of Temperature on the Initial Respiration Rate of Wagener.

In addition to the respiration experiments at 68.5° F., determinations were made of the carbon dioxide evolution of Wagener apples at 32° F., 40° F., 48° F. and 86° F. The fruit used was picked October 5, in the midst of the commercial picking season for Wagener. Table II gives the average rates for two experiments at each of the above mentioned temperatures and the average of the first runs of 10 experiments at 68.5° F. This gives a comparison showing the effect of temperature on the initial respiration rate after picking.

Table II.

Mean temperature		
Degrees F.	Degrees C.	Milligrams of CO_2 per kg. hr.
32.5	0.25	3.10
40.2	4.55	5.05
48.3	9.05	7.50
68.5	20.20	11.96
86.0	30.00	24.37

These results agree with the findings of Gore (1). The rate of carbon dioxide evolution increases according to the temperature coefficient rule, usually referred to as "van't Hoff's Law."

Effect of Storing for a Period at 32° F. on the Subsequent Respiration Rate at 68.5° F.

Although it has been known for a long time that a rise in temperature is accompanied by an increased respiration rate in apples, no reference has been found to any stimulation as a result of the change in temperature itself. Early in the course of the present work it was found that immaturely picked Wageners and Baldwins, stored at 32° F. immediately after picking, respired at an abnormally high rate when transferred to 68.5° F. A number of samples taken at successive intervals through the season are stored for varying periods at 32° F., then removed to 68.5° F., given a day to warm up, and the rate of carbon dioxide evolution determined. The results are given in Table III. The checks consisted of fruit picked at the same time, but started immediately.

In the case of Wagener it is apparent that the earlier picks were markedly stimulated. In some cases the rate after removal from cold storage was actually greater than that picked at the same time and held at 68.5° F. for an equal period. In other experiments the increase occurring after a time at 68.5° F. brought the rate of the check up to or above that of fruit held in cold stor-

age for an equal period of time. However, the comparison cannot be made merely in terms of time. A change such as the increase in respiration rate after picking, shown in Table I, is probably delayed by low temperature. In the experiments at low temperatures no marked increase in respiration rate occurred in the first three weeks after picking. The softening process, the change in ground color from green to yellow, and the loss in acidity, all of which are ripening phenomona, are retarded by low temperatures. The data show that in later picks this increase was retarded, so that it is apparent that in early picked fruit, where no such retardation occurred, there was some stimulation due to previous cold storage.

In the tree ripe samples of Wagener, picked after October 1, the initial rate is midway between the initial rate of the checks and the maximum rate attained. There is a general rise after the first run, somewhat the same as in the checks, but entirely different from earlier experiments, where the rate started high and went down. Apparently the maturely picked fruit was stimulated less by temperature change than the immaturely picked samples.

The possibility of a connection between the effect of cold storage on early picked Wageners in this respect, and their poor keeping quality, suggested itself.

TABLE III.

Effect of holding for a time at 32° F. on the subsequent respiration rate of apples at 68.5° F. All samples stored at 32° immediately after picking and given 1 day to come to 68.5° F. before determinations were started. Duration of runs in days indicated above rate figures.

Exp.	Date picked	Number of days at 32° F.	Milligrams of CO_2 per kilogram hour.					
			Run No. 1	Run No. 2	Run No. 3	Run No. 4	Run No. 5	Run No. 6
			Wealthy					
1	Aug. 14	14	2 33.40	3 36.00	3 31.10	2 26.50	3 35.20	.....
8	Aug. 14	check	2 14.73	3 27.00	3 29.90	4 36.05	.....	.....
9	Aug. 30	7	2 24.36	3 29.70	3 30.01	3 27.00	.....	.....
10	Aug. 30	13	2 29.34	3 35.76	3 33.46	3 33.90	.....	.....
7	Aug. 30	check	2 23.24	3 31.60	3 33.80	3 31.58	.....	.....
19	Sept. 7	57	3 31.65	3 33.58	.....	.....	.....	.....
			Baldwin					
6	Sept. 4	10	3 22.52	3 23.18	4 24.88	3 22.50	.....	.....
4	Sept. 4	check	4 11.78	3 11.00	3 19.02	3 20.46	.....	.....
			Wagener					
1	Aug. 14	15	2 18.30	3 17.96	3 20.88	2 17.46	3 20.70	.....
4	Aug. 14	check	3 12.90	3 18.00	3 10.97	4 10.78	.....	.....
8	Sept. 2	7	4 15.58	3 17.61	3 17.70	3 19.61	3 18.02	.....
12	Sept. 2	15	3 19.08	4 18 14	3 15.71	4 16.85	4 16.55	.....

6	Sept. 2	check..........	$\overset{2}{10.41}$	$\overset{3}{12.97}$	$\overset{4}{9.73}$	$\overset{3}{10.78}$	$\overset{4}{13.44}$	$\overset{3}{18.55}$
15	Sept. 11	9..............	$\overset{4}{18.84}$	$\overset{3}{19.18}$	$\overset{4}{18.35}$	.....	.....	.....
20	Sept. 11	15.............	$\overset{3}{15.00}$	$\overset{4}{19.76}$	$\overset{4}{18.88}$	$\overset{4}{17.12}$	$\overset{3}{17.58}$	.....
10	Sept. 11	check..........	$\overset{3}{10.03}$	$\overset{3}{10.52}$	$\overset{3}{11.55}$	$\overset{3}{15.40}$	$\overset{3}{17.45}$	$\overset{3}{19.00}$
16	Sept. 18	6..............	$\overset{3}{12.65}$	$\overset{3}{16.66}$	$\overset{4}{18.28}$	$\overset{4}{23.20}$	.....	.....
13	Sept. 18	check..........	$\overset{3}{10.11}$	$\overset{4}{10.80}$	$\overset{3}{11.26}$	$\overset{4}{16.49}$	$\overset{4}{18.04}$	.....
21	Sept. 25	2..............	$\overset{3}{18.62}$	$\overset{4}{16.66}$	$\overset{4}{19.90}$	.....	.....	.....
33	Sept. 25	15.............	$\overset{4}{18.76}$	$\overset{4}{21.11}$	$\overset{5}{15.80}$	$\overset{3}{18.90}$	.....	.....
18	Sept. 25	check..........	$\overset{3}{11.55}$	$\overset{4}{15.08}$	$\overset{4}{22.90}$	$\overset{4}{20.64}$	$\overset{4}{18.26}$	$\overset{4}{15.95}$
35	Oct. 4	12.	$\overset{2}{16.68}$	$\overset{4}{17.92}$	$\overset{4}{19.64}$	$\overset{4}{21.38}$	$\overset{3}{21.09}$	$\overset{3}{19.57}$
26	Oct 4	check.....	$\overset{3}{13.13}$	$\overset{4}{14.63}$	$\overset{3}{18.92}$	$\overset{4}{18.56}$	$\overset{4}{18.56}$	.....
40	Oct 8	18.............	$\overset{2}{14.06}$	$\overset{3}{18.52}$	$\overset{3}{21.04}$	$\overset{3}{18.46}$	$\overset{3}{19.12}$	$\overset{3}{17.20}$
27, 28, 29	Oct. 8	check..........	$\overset{2}{11.30}$	$\overset{3}{14.70}$	$\overset{4}{16.50}$	$\overset{4}{17.60}$	$\overset{4}{15.50}$	.....
39	Oct 12	14.............	$\overset{2}{16.06}$	$\overset{3}{20.80}$	$\overset{3}{21.02}$	$\overset{3}{23.23}$	$\overset{3}{21.28}$	$\overset{3}{18.74}$
34	Oct 12	check..........	$\overset{2}{13.49}$	$\overset{3}{21.02}$	$\overset{4}{20.82}$	$\overset{4}{17.96}$	.....	.....

Other Changes Occuring During the Ripening Season

In addition to the respiration experiments, already discussed, a number of samples of Wagener were tested for hardness, and samples taken for analysis, at successive intervals through the season. At the time the tests were made, concomitant lots were placed in storage. The weekly mean temperatures of the cellar, and of the outside air, during the period covered by the tests are given in Table IV.

TABLE IV.

Weekly Mean Temperatures at the Marble Laboratory, Inc., Fall of 1922

Week ending	Weekly mean temperatures: Cellar	Weekly mean temperatures: Outdoors
September 4........................	64.0 ° F.	65.0 ° F.
September 11........................	67.2	68.1
September 18........................	63.1	57.1
September 25........................	58.0	56.3
October 2........................	55.8	58.4
October 9........................	61.5	62.7
October 16........................	55.3	53.0
October 23........................	49.1	41.7
October 30........................	45.3	39.1
November 6........................	45.9	44.5
November 13........................	46.8	40.5
November 20........................	44.0	38.6
December 4........................	41.0	34.7
December 11........................	40.0	29.0

The determinations of hardness were made by means of the pressure tester described by Murneck (8). Samples were taken from three trees at four different times from September 23 to October 24. Each sample consisted of 15 apples, and five tests were made on each apple. The figures given are average of the three

trees, hence each figure is the average of five tests on each of 45 apples. In order to compare the rate of softening on the tree with that of picked fruit, pressure tests were made on samples held under various storage conditions, 45 apples being used for each sample. All the pressure tests were made with the skin removed. The results are given in Table V.

TABLE V.

Pressure tests on Wagener apples, 1922. Each figure is the average of five determinations on each of forty-five apples. Skins removed.

Date tested	Immediately after picking	Pressure in Pounds After Storage in Cellar	40 ° F.	32 ° F.	Orchard
Sept. 23	18.42	.....	.....	.....	.....
Oct. 3	18.10	.....	18.10	18.10	.....
Oct. 2-7	.....	17.88	.....	.....	.....
Oct. 13	17.65	.....	.....	.....	.....
Oct. 16	.....	16.56	.....	.....	.....
Oct. 24	15.07	.....	.....	.....	15.07
Oct. 28	.....	12.77	.....	.....	.....
Nov. 6	.....	10.33	13.44	16.35	.....
Nov. 21	.....	9.34	11.18	.....	11.36
Dec. 6	.....	9.46	10.70	14.58	.....

The softening of Wagener on the trees amounted to only three-fourths pound from September 23 to October 13, a period of three weeks which includes the commercial picking period of the variety, October 2 to 9. At the beginning of this period the fruit was not ready to pick, at the end it was perhaps beyond the optimum condition for picking, yet the pressure tests showed little difference. Lewis, Murneek and Cate (2), and Murneek (8), found that during the shipping season Bartlett pears softened at the rate of a pound in two of three days. Bosc pears softened about a pound in six days. Unless other varieties soften more rapidly than Wagener through the repening season, the pressure test is not practical as a picking test for apples.

From October 13 to 24 the resistance to pressure of the fruit declined about 2½ pounds. Athough softer, the fruit still retained its green-apple taste. This period was well beyond the usual picking time for Wagener, yet there was little dropping. The fruit left on the tree until October 24 was about as hard then as fruit picked three weeks earlier and held at 40° F. This same fruit, picked October 24 and stored in an uninsulated shed in the orchard until November 21, was harder than fruit picked three weeks before and stored in the cellar until that date, and as hard as fruit stored at 40° F. The late picked Wageners also had better color and much higher eating quality, than earlier picked apples.

Comparing the softening rate on the tree with that of apples in storage, it will be seen that the fruit in the cellar, where the mean temperature was only a little higher than the mean temperature outside, softened more rapidly. No data were obtained as to the relative softening of early and late picked fruit at the same temperature, but observations indicated that at 68.5° F. early picked fruit retained its hardness a little longer.

A number of determinations of the percentage of fixed acids were made on Wagener at successive intervals through the season. The method described by Magness (3) was followed. The results are omitted, but it may be stated that there was some decrease in percentage of acid through the season.

When the samples for acid determinations were taken, duplicate portions of pulp for moisture determinations were placed in tared weighing bottles and stoppered until the other samples had been attended to. The bottles were then weighed and the tissue covered with 95 per cent alcohol and set aside. When a number had accumulated, the samples were dried to constant weight in a vacuum at 70° C. The duplicates checked very closely. The percentage of dry weight of successive samples are given in Table VI.

TABLE VI.

Percentage of dry weight of Wagener apples at successive intervals through the ripening season, 1922.

	Percentage of dry Weight			
Date picked	Tree No. 1	Tree No. 11	Tree No. 12	Tree No. 13
Sept. 23	.....	12.47 13.32	12.67	13.17 .....
Oct. 3	.....	13.29	13.00	13.53
Oct. 10	13.99	13.48	13.36	.....
Oct. 24	13.47	.....	.....	14.14

While there was considerable variation between samples picked at the same time, in general an increase in dry weight through the season is indicated. Magness (3) found an increase in dry weight of Bartlett pears from the middle to the end of the commercial picking season in California. The data in Table VI suggest that the apples continued to receive carbohydrates from the leaves during most of the period covered by the sampling. The leaves were not killed until about October 21.

DISCUSSION OF CHANGES OCCURRING DURING THE RIPENING SEASON

In drawing conclusions from the experimental results reported above, it must be kept in mind that the greater part of the work was on Wagener, an early winter variety, which softens very rapidly after picking when held at ordinary temperatures. This variety is known to scald badly in storage when poorly colored, or immaturely picked. Well colored, mature Wageners are comparatively free from this trouble (10). In this connection, any changes occuring during the period when the fruit is maturing are of interest. Some points of difference between early and late picked samples have been found.

Storing for a time at low temperature stimulated the respiration of immaturely picked fruit after removal to high temperatures more than of maturely picked fruit. When the respiration of Wagener apples was determined immediately after picking, it was found that the rate increased more quickly, and stayed at the maximum longer in the tree ripe fruit than in early picked apples. The same appeared to be true of Baldwin. The initial respiration

rate of all the varieties studied was about the same through the possible commercial picking season. There was a decrease in titratable acidity, but an increase in dry weight of Wagener as the season progressed. Wagener did not soften much for the three weeks covering most of the possible commercial picking season. They kept their green-apple taste as long as they were left on the tree. The ground color took on more yellow as the season went on, but did not lose its green tinge as long as the fruit remained on the tree. The last picks were of higher quality for eating, and had better color, than fruit picked during the commercial picking season.

These facts indicate that while the fruit keeps its connection with the tree, there is a retardation of the ripening, or breaking down process. Off the tree, low temperature exercises a retarding influence on ripening. Apparently the same thing occurs when the apples are left on the tree, even with high outside temperatures. Lewis, Murneek and Cate (2) found the softening of Bartlett pears to be retarded by connection with the tree. They suggest that high temperatures may have delayed the softening on the tree as they are known to do in storage (11). As the mean temperature at Canton was below 60° F. during most of the period in question, it does not seem that extreme temperatures could have been the cause of the retardation of the ripening and softening processes.

It is evident that if cold storage was not available, the best place to store Wagener during a warm picking season such as we had from Sebtember 25 to October 16, was on the tree. Had this been done the quality of the fruit would have been higher, and the high storage temperatures prevailing during this period would have been avoided. Whether such a proceedure would be practical for other varieties would depend on the rapidity with which the apples matured on the tree, and on the tendency of the variety to drop. In many cases it might be worth while to risk a loss from dropping to get the advantages of better color and quality, and freedom from scald, resulting from late picking, and of starting the common storage season during colder weather than would be possible with early picking.

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Helpful Points in Fruit Identification

By H. B. Tukey, *Experiment Station, Geneva, N. Y.*

THOSE who handle fruit, from the housewife to the fruit-grower, desire to know the names of the varieties with which they are dealing. The resulting demand for identification undobtedly varies in different localities, but at the New York Agricultural Experiment Station at Geneva, hundreds of varieties are received for identification each season. In fact, scarcely a day passes that several fruits do not arrive. The work is a heavy drain upon both time and energy.

Frequently the specimens are identified at once, but often they are not, for the varieties that the pomologist receives for identification are mostly those that the neighbor, the fruit-grower, or the farm advisor, does not recognize. At all events a most thorough and careful examination must be made so that no daughter seedling will be called by its mother's name. The usual course of procedure is first to note the varieties that suggest themselves, and second to compare the specimen in hand with technical descriptions of these possibilities, or with fruit from the variety orchard. But this cut and try method takes time, especially when the orchards are at a distance, and technical descriptions, though helpful, are not positive.

Moreover, like the face of an acquaintance, a variety may seem perfectly familiar, but no name comes to mind. A case in point was the writer's experience the past season when a variety of apple that had a vexingly familiar appearance reposed on his desk for fully three weeks before suddenly it fairly shrieked its name. Again, the more perishable fruits are often received in very bad condition and sometimes only one specimen is sent, and that not characteristic of the variety. Almost any suggestion, then, that will help in identifying varieties, ought not to be too

severely condemned; and since the first step in identification lies in recalling possibilities, a system of bringing to mind possible varieties, or limiting their numbers suggests itself, namely, a system of classifying, grouping, or keying varieties.

At once the objection is raised that most classifications, groupings, and keys are valueless excepting to the authors. The reply is that this alone is sufficient justification for their existence and with the added advantage that someone else *may* be able to use them.

Now a classification and a key are two different things. A classification is established along natural lines, a key will more often be artificial. A classification permits of expansion and contraction, whereas a key begins with a restricted group of varieties and endeavors to make each variety distinct. The classification belongs more to the initiated and serves as an aid to memory in associating the more uncommon sorts with the more familiar ones. A key is more often of use to the novice, who ordinarily deals with a smaller number of varieties and desires to be able to run a variety to its source easily and quickly. The more nearly a key can follow a natural classification the better it will be, and the more easily expanded and contracted as new varieties demand a place.

So long ago 300 years before Christ, Theophrastus classified varieties of fruit. Since then the schemes advanced in various parts of the globe have been numerous and varied. More attention has been given to this kind of work in Europe than in America. In Europe the pomologist has worked along natural lines so far as possible and has busied himself for the most part with groupings and classifications, while Americans have broken away and turned to the very arbitrary key. This difference is worthy of note it indicates the difference in pomology on the two continents.

American fruit-growing is characterized by its commercial aspect; European, by its amateur. In America the varieties of fruit commonly met with are relatively few; in Europe the varieties in cultivation are numbered by the thousands. It will be recognized at once that it would be impossible to make a key that would handle satisfactorily this multitude of varieties. Consequently the arrangement of varieties into families and orders and classes and groups has been resorted to. But the handicap of using such a scheme is evident from an examination of some of the better systems. Such systems as the Diel-Lucas (1)* classification for apples with its fifteen main divisions and hundreds of separate groups are remarkable in their scope, but ponderous. Moreover, they assume a fair acquaintance with varieties before the schemes can be used. So that while it is of considerable aid to the expert's memory to know whether a variety belongs among the Schlotter apples, or, to use a grouping used in this country, is a member of the Aport group, it means little to others. Again, the European classifications have followed the natural plan. Contrast this with the very arbitrary and extremely simple classifications or keys of Warder (2) and Thomas (3) in America based on shape, flavor, color, and season.

*Citations to literature by number.

Botanists have resorted to keys, but they have had the advantage of being able to use fruit, flower, leaf, and tree characters, while a truly serviceable key for the identification of fruit varieties must be one based upon fruit characters alone. To be sure, Lindley (4) and Dochnahl (5) both used tree characters in their classifications, but rather to the discredit of the systems. It would be fairly easy to work out a botanical scheme, for progress has already been made in identifying fruit varieties by their leaves in this country (6), and by their twigs (7) and flowers (8) in Europe. In his effort to work out some scheme the pomologist has resorted to every conceivable fruit character, from specific gravity (10) and molecular weight on the one hand to internal characters on the other (9).

For American conditions, then, because the horticulture of the country is peculiar in its extensive growing of a limited number of varieties, and because there are relatively few specialists in fruit identification in a region so large and varied, it would seem that a purely artificial key covering a limited number of varieties would be best. Such a plan is objectionable because it does not allow for contraction and expansion. It is built to fit a select list of varieties and if one is dropped, or another added, the key must be correspondingly changed. Nevertheless, the advantages far outweigh the disadvantages and the New York Agricultural Experiment Station at Geneva is endeavoring to work out a system keying the varieties listed in Hedrick's "Cyclopedia of Hardy Fruits."

It is recognized that the varieties for one region not only will vary in appearance in other regions, but also the list itself will be different. Perhaps foot notes recording regional peculiarities in shape, appearance, and so on could be used to make the key fit a wider range. Morever, the requirements of a key vary, that is, a key for the farm advisor should not be cluttered with unimportant varieties, while on the other hand a system for the pomologist should contain many rare and minor sorts. So then, there should be as many keys as there are necessities for them, yet underlying all will be a few fundamental principles.

In the first place, no arbitrary system can be used for all classes of fruits. Whereas, season and flavor would probably stand first in a key for apples, they would be well down the list, or totally disregarded for grapes. While length of stem is very useful in keying cherries, it is of doubtful value in work with apples and pears (11) (12), and though adhesion of the stone in plums and peaches is one of the most important aids in identifying those fruits, it is practically worthless for cherries. The best method of procedure is to weigh the various characters and place the most dependable ones first.

With grapes, a key based on the more reliable fruit characters will likely have as the first division "slip skin" vs. "not slip skin," to separate the European grapes from the American sorts. Next will probably come the color of the berry, making three more classes, namely "black," "red or brown," "yellow or green;" then will come the shape of the berry, "distinctly oval" or "round-

ish;'' and finally will come the color of the brush—a very good character and usally overlooked—''greenish or with reddish tinge'' and ''wine color.'' Perhaps now the size of the berry may be used to take out the extremes, ''large,'' as Hercules; ''medium,'' as Concord; and ''small,'' as Clinton. Season may now be brought in, best compared with familiar sorts as ''Very Early, ripening with or before Winchell;'' ''Early, ripening with Moore Early;'' ''Early Mid-season, ripening with Worden;'' ''Mid-season, ripening with Concord;'' ''Late Mid-season, ripening with Vergennes:'' ''Late, ripening with Catawba;'' and ''Very Late, ripening after Catawba.''

Cherries offer a system very closely approaching a natural one. Sweet cherries and sour cherries constitute the first two groups. The sweet cherries may then be divided into ''soft-flesh'' (Hearts) and ''firm-flesh'' (Bigarreaus), each in turn being further divided into those with ''dark flesh'' and those with ''light flesh.'' In the sour group the first division is ''mildly acid'' vs. ''strongly acid,'' which separates the Duke cherries, for the most part, from the sour cherries. Now the color of the flesh may be employed dividing the dark flesh ''morellos'' from the light flesh ''amarelles.'' From here on the system departs from the natural scheme and becomes purely artificial. A division may be made of cherries ''higher or taller than wide'' and another ''wider than high.'' Again the stem may be ''long (more than ½ inches)'' or ''short (1½ inches or less).'' Last of all will come season on a basis of the time of ripening of Black Tartarian, Yellow Spanish, and Windsor for the sweet cherries, and Early Richmond, Montmorency, and English Morello for the sour cherries.

With peaches and nectarines the season plays a more important part. First will come ''skin smooth'' and ''skin pubescent'' to seperate the nectarines from the peaches; then stone adhesion, ''clingstone,'' ''freestone,'' and possibly ''semiclingstone;'' and finally season in relation to the better known sorts. The groups will now be so large that some further means of differentiation must be employed, and this brings us to a discussion of the ''visible'' key.

George Bunyard (13) in England has worked out a very novel and extremely interesting key of the so-called ''visible'' type for both apples and pears. He divides pears into summer, autumn, and winter sorts and then, devoting a sheet to each of these groups, proceeds as follows. Across the top of the sheet are six forms of pears graphically represented; at the left margin of the sheet the months of the year are printed. The varieties are now arranged on the sheeet under the vertical column corresponding to their shape and at the same time in the proper horizontal column for their month of ripening. Large sorts are in capital letters, medium-sized sorts in small letters, and small sorts in italics. Further, an asterisk after a variety designates one with a red cheek; a dagger, one smooth green; and a double dagger, entire russet. An obvious advantage is that varieties intermediate in form may be placed astride the two columns

with which they most nearly agree, likewise for season.

Mackintosh (17) (18) has done something the same for peaches in this country by grouping the varieties on their more important characters and then listing the varieties alphabetically at the left hand margin of a sheet with the various fruit characters arranged across the top. Stars are placed in the columns corresponding with the characters of a given variety.

Now such schemes have some excellent qualities. They are especially valuable to the expert who often receives but one specimen of a variety, and are particularly useful in the identification of the perishable fruits. A plum may be in such poor condition upon its arrival that its shape is indeterminable, yet if the color and stone adhesion can be recognized, a glance at the visible key will give at once the possible varieties with these characters in common.

After the variety to be identified has been run down through the key to a small group of possibilities, the next step is its final checking up and verification. Technical descriptions are valuable at this point though specimens of fruit are better. Too often fruit cannot be easiy secured, if at all. One of the helps now is to have noted in the key the salient or distinguishing features of the varieties. For example, the Bradshaw plum usually has a fleshy ring about the stem at the base, and the stone is long necked; Grand Duke is a clingstone and Arch Duke a freestone. The Duchess grape is characterized by its translucent berries with russett dots; Campbell Early by its firm, tough flesh and dark red brush; Empire State by its long branching peduncle. The berries of Vergennes have russet dots; Agawam is distinguished from Salem by seeds with warts and raised dots; most of Roger's Hybrids have beaked or elongated seed; Wyoming, Lutie, and Lucile, all foxy, red grapes of about the same season, are differentiated by the chalaza, that of Wyoming being obscure, of Lutie distinct and circular, while of Lucile distinct but oval or elongated. The Lyons cherry is characterized by a firm, dark flesh strongly adherent to the stone. The characteristic aroma and open core of McIntosh distinguish it from Fameuse with its closed core. The suture line on Tolman Sweet; the concentric, broken, russet rings about the calyx of Hubbardston; the rough pimpling of Twenty Ounce; the wide flaring cavity of Rome Beauty; the star-shaped calyx in the shallow basin of Beurre d' Anjou; and the stiff, erect calyx segments of Seckel as contrasted with the slightly recurved calyx segments of Worden Seckel, are all "ear marks" of recognition. Every one of these points is marked enough to distinguish the variety to which it applies without further ado.

But for some varieties it is difficult to find clear cut characteristics that will identify them. For this purpose graphic records of shapes and internal characters will be found helpful. Durham (14) has indicated the importance of tracings of longitudinal sections, transverse sections, and crown sections, showing outlines of the core-limit, carpels, fibro-vascular bundles, Truelle's

line, calyx, and stem. He has further shown the shape of the carpels in cross section and of the "axial sac"—that is, the intercarpellary space—in both cross and longitudinal sections, to be valuable points. Truelle's line has been a contemplated basis for fruit identification, and though it is of definite value it is too refined a point for general use. In pears the ratio of the height to the breadth (15) (16), and the ratios between the distance from the base of the stem to the base of the seed-cells (9), and the distance from the base of seed-cells to the calyx are considered good points. In short the number of characters in fruits little known, or yet to be found, are numerous and their value not yet fully appreciated.

Perhaps the greatest help in verification of varieties is a collection of seeds. In fact grape seeds are so characteristic and so constant that a key might be made based upon them alone. Cherry, plum, and peach seeds are also useful; while pear and apple seeds, though valuable, are useful in a lesser degree.

All seeds look alike to some, but in reality they offer a large number of clear points of demarcation. To mention a few of the important characters that may be noted: the seed of the grape may be broad or narrow, short or long, blunt or pointed, or necked; the raphe may be distinct or indistinct, or cord-like; the top of the seed may be rounded or notched; the chalaza may be raised or sunken, obscure or distinct, it may be located above, at, or below the center, and it may be smooth or wrinkled. Cherry seeds may be wider than high, taller than wide, thicker than wide, or wider than thick; they may be pointed or blunt; the dorsal suture may be narrow or wide, narrow at the apex or broad at the apex, with ridges prominent, or with ridges almost wanting. Plum seeds may be rough or smooth, winged or not, pointed or blunt, necked or not necked, wide or narrow, thin or plump, oblong or round, or even rudimentary,—and so on through constant and reliable points far too numerous to mention and others yet unnamed.

For ease in handling, the seed are best kept in glass vials with screw caps. For grape, apple, pear, and cherry seed, round four-dram homeopathic vials are a good size. For plum and apricot, square two-ounce bottles, 1½ x 1½ x 3 13/32 inches; and for peach and nectarine, square four-ounce bottles, 1 13/16 x 1 13/16 x 4½ inches, are satisfactory. The names written on cards or stiff pieces of paper and inserted in the vials, and the whole placed horizontally in a case with shallow drawers, completes one of the most valuable and serviceable adjuncts to fruit identification.

To sum up the case, then, the heavy demand for fruit identification urges the development of aids in the work. The first suggestion is the grouping, classifying, or keying of the varieties most frequently met with, using only the more reliable and evident fruit characters, following this, for final verification, with numerous internal and external fruit characters—some very good ones yet unnamed. The difficulties and labor involved in the development of any of these helps cannot be underestimated, yet the

value and satisfaction derived from the correct naming of fruit varieties insists upon the effort.

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Some Effects of Fall Application of Nitrogen to Apple Trees

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IN a paper read before this society last year, it was shown that the nitrogen content of apple-spurs a year after a spring application, was neither increased nor decreased to any marked extent, but that summer and fall applications produced a distinct increase, and the later the application the greater the increase. The severe freeze in the spring of 1921 made it impossible to determine any subsequent

effect of this increased nitrogen content. In the fall of 1921 nitrogen fertilizers were applied to York Imperial trees in two orchards near Columbia, Missouri, in order to complete the previous experiment.

In one of these orchards belonging to Dr. Howard, fertilizer was applied to four plots on September 27, 1921, and a fifth plot was left as check. To each tree in one plot 5 pounds of nitrate of soda were applied, in another 10 pounds of nitrate, in the third 3½ pounds of ammonium sulfate, and in the fourth 7 pounds of ammonium sulfate. In the spring and summer of 1922, samples of bearing and non-bearing spurs were collected and analyzed. The most significant data obtained were starch determinations on the non-bearing spurs collected July 3:

	Starch content in percentages of dry weight
Fall fertilized with 10 pounds nitrate	1.69
Fall fertilized with 5 pounds nitrate	2.44
Fall fertilized with 3½ pounds ammon. sulfate	2.31
Check	0.72

Unfortunately no starch analysis was obtained from the spurs on the plot fertilized with 7 pounds of ammonium sulfate. These determinations seem to indicate that fall applications of nitrogenous fertilizers increase the starch content of the non-bearing spurs at the time when fruit-bud differentation usually occurs. However, the experiment is not conclusive because it so happened that although these trees blossomed little or none and bore no crops in 1921, those trees that had been selected as checks blossomed more in 1922 than the fertilized trees. Of course the fertilizer treatment had nothing to do with this, as the application was made many months after the fruit buds had been formed, but this may explain in part the smaller amount of starch accumulation in the check trees. One point, however, is clear. The trees treated with 5 pounds of nitrate or 3½ pounds of ammonium sulfate, accumulated more starch in their non-bearing spurs during June than the trees treated with 10 pounds of nitrate.

The second experiment was carried out in Riverview Orchards near McBaine, Mo. All the trees used in this experiment had been fertilized with nitrate in the spring of 1921. On August 14, a number of trees were treated with 5 pounds of dried blood of a high grade. On September 19 another plot was treated with 5 pounds of nitrate to the tree. A third plot was left as check. If the check trees in Dr. Howard's orchard blossomed more than the treated trees, the check trees in this orchard blossomed less and bore a much smaller crop. Nevertheless, the starch determinations made on non-bearing spurs July 8, 1922, show greater starch content in the treated than in the untreated trees:

	Starch content in percentages of dry weight
Summer application of 5 pounds dried blood	2.18
Fall application of 5 pounds nitrate	2.25
Check	1.58

These figures indicate in a more convincing way that nitrogen applications made late in the season tend to increase the chances for starch accumulation in the non-bearing spurs the following June.

Fruit-bud differentiation depends on two sets of factors: (1) all those conditions that make for growth, and (2) those conditions that in addition bring about starch accumulation in the spurs during June. In the paper previously referred to, data were presented to show that spring applications of quickly available nitrogen on trees in good growing condition reduced the chances for starch accumulation in the spurs during June. The data just presented indicate that late summer or fall applications may increase these chances. When these findings are substantiated by further work, they may prove to be of considerable importance in orchard management.

Spring applications of nitrate of soda to apple orchards usually increase fruit-bud formation as well as stimulate growth. This is because most orchards are starved or semi-starved for nitrogen and because an improvement in the conditions that make for growth is also an improvement in the conditions that determine fruit-bud differentiation. But as more and more nitrogen is applied to apple orchards, spring applications of nitrate probably will not be accompanied by increased yields except as the set of fruit is increased. On the contrary, they may eventually be accompanied by decreased yields. It would seem that under such conditions, late summer or fall applications of nitrogen may prove of value. Such a treatment supplies the tree with nitrogen just as the spring treatment, only the nitrogen is stored in the plant over the winter instead of being used immediately in new growth. The delayed treatment has the advantage over the spring treatment under these circumstances in that it does not tend to decrease fruit-bud formation, but rather appears to favor it.

Since spring applications of nitrogen increase the set and tend to decrease starch accumulation in June on trees in good growing condition, it would seem inadvisable to apply nitrogen to alternate-bearing varieties the spring of the bearing year. It would seem practicable, however, to supplement spring applications in the off year with late summer or fall applications. In this connection it is interesting to note that Hodgsoll reports in the Journal of Pomology (1:217-223. 1921) that alternate bearing varieties in England have been made regular producers by supplementing the usual spring applications of nitrogen with August applications of manure.

Administration a Vital Factor in the Development of a Department of Horticulture

By J. C. Blair, *University of Illinois, Urbana, Ill.*

SUCCESSFUL administration means not only the direction, or the management of an office or employment, but it also means organization. To build a successful business of whatever nature,

the foundation, or the organization, must be carefully planned and built accordingly. This is true in any business. Especially is it true in the development of a department of horticulture in any institution. It is equally true even though there are but two people at work in the department.

In the development of a department in a college, there are certain problems that assume surprising proportions, but if the department happens to be a subdivision of an agricultural college, then, the problems seem to multiply and unexpected ones appear with great rapidity and regularity. If you will look carefully into the work and accomplishments of many of our horticultural departments, you will wonder, I am sure, how many of them could have attained the success they have with so little or no attention being paid to the matter of organization and administration.

This is a day and age of organization. System is everything. Mr. H. G. Wells says, "The *old system* of life was organization.... To organize, or discipline, or mould characters, or press authority, is to assume that you have reached finality in your general philosophy. It implies an assured end. All organization with its implication of finality is death. What you organize you kill." I do not agree with this statement, because it is not borne out by the facts.

I believe that organization and specialization properly applied produce incalculable benefits. I believe that system in our work is not only necessary, but it may be everything. Every industry that I know of, that is successful, is so because of some central authority or direction—some centralized way of attacking its problems. If there is one thing above all other that the American business man is proud of it is his organization. With him it very often becomes a passion, and I have known men who have spent their lives studying and promoting it.

What is organization, and how does it apply to the administration of a department of horticulture? Organization, as I use the word, is the act or the process of arranging and getting into proper working order the various parts of an aggregate, or group of persons, for action. To have any kind of a department in a college, or industry, we must find a definite plan of organization and administration. Certainly we cannot have administration without the organization, which to my mind is the fundamental thing in the building of any business.

Do away with organization and all that is left is a blank, confusion, discord, duplication, defeated purposes, and death. Growth would be restricted and mental, social and industrial decay would soon set in.

There are, of course, good organizations and bad organizations as well as mediocre organizations. For a type of the good organization with high specialization, think for a moment of Henry Ford's auto plant at Detroit. Has he not benefited his employees and his associates far more than any gain he may have experienced for himself? Has he not given the world a better car for less money than any other manufacturer? Has he not turned out more

cars per hour than any other auto plant in the world? Why? Because of his splendid organization with its high specialization and efficient management, or administration. It is not the quality, intrinsic value, or the volume of the product that I desire to emphasize by this example of organization, but rather the real social service rendered by this organization both to the public and to the employees.

Yet, Mr. Wells says, "All organization, with its implication of finality, is death." There is no finality about good organization. There is, however, a temporary standardization of methods, so that creative effort may be liberated in order to devise better means. Organization can and does build men. Constantly it is searching for the qualities of leadership, of invention, and of executive ability. In fact, good administration is a vital factor in the development of a department of horticulture.

There are two ways of building up a department. First, by taking a group of apparently capable men and making places for them, or second, by outlining the skeleton of the organization, then fitting men in as they are needed, and as the capable person for the position is found. We realize at once, I am sure, that the second method builds faster toward a permanent and successful department. But, who is to select these specialists as they are needed? Paramount among the certain elements of a successful organization is this leader, or chief executive; the administrator, if you please.

In nearly all colleges the department is the unit of organization. To have forcible and aggressive departments, a central power of coordination is essential to progress, either in research, instruction, or extension work. But, what is needed to build a forcible and aggressive department? Should not the first consideration be to obtain an executive, gifted with clear thinking and vision, with knowledge and will power ever to be exerted toward improvements, economies, betterment and progress? A real man is needed—one capable of commanding the regard and respect of his subordinates, whose very presence holds the morale of the workers; one who is never lax or over-exacting in the management of his organization; a person of understanding and experience, of training and natural ability and infinite patience. The chief executive is, or should be, the highly charged battery brimming over with dynamic force and infectious energy. His energy is, or should be, transmitted through an established line: his assistants and co-workers. It is necessary for him to create in the minds of his staff that quality which puts spirit, ambition and initiative into their work and makes each determined to be in line for commendation and promotion.

The man entering an organization must be close to it; he must be imbued with the feeling that the department is his personal investment, if he would be efficient and successful.

In nearly all departments either in a college or industrial plant, although perhaps more so in the latter, yet not unknown in the former, there are invisible barriers of varying densities. Every executive comes in contact with them. There are barriers of

common human inertia, barriers of open opposition, of conflicting personalities, petty jealousies, and often they are rather a combination of all these elements working in harmony with mass psychology. There are some men who seem to be born organizers, and with no apparent effort whatsoever, build around them a loyal and enthusiastic organization of men whose efforts carry him and them to the highest pinnacle of success. Other men, and I am acquainted with several such cases, have been placed in authority and despite sincere and worthy efforts have only made themselves a center of discord and repressed antagonism. So, we must find mutual confidence and understanding between the head of a department and the personnel. Mr. Jay E. House makes the statement that the efficiency and morale of any business depends upon the loyalty of the subordinates to the head of the business. This I believe to be very essential.

The whole world seems to think and agrees that it is the accumulative annoyances of little things rather than the effect of the big things that count in the long run. We get the single effect of the forest without thinking of the accumulative effects of storms, drought, fires, etc. Nature drives the roots deep and groups the trees together, as a defense against the storms and other forces; but surely in the beginning, she must have experienced these things, or she would be unable to supply them.

So, in the business of developing a department, the single effect is that of building toward success. We do not think of the myriad of little things that go into the building up of the business activity of the organization. Often in the business world I have heard statements made to the effect that only a detail man can attend to these little things; that a detail man is best to fill the position of executive. He is popularly supposed to be a man of limited executive ability and without much vision. The majority of executives are assumed to possess no gift for detail whatsoever; they are considered born executives. Seldom does it occur to any one to wonder why or how they become leaders, or by what process or training each acquired the knowledge to make him the logical man for the administrative position. The secret of his success as an executive is that he possesses the ability to select and direct others in the details of the work. Subordinates often take it for granted that "the boss" is too big a man to know anything about the routine handling of the details. If he knew nothing of the details how could he select the men to handle them? Most big men have begun at the bottom and worked up to the top, which consists only of bigger detail.

The head of a department does not necessarily need to be an instructor or an experimentor, nor does he necessarily need to use the same language as the instructor or the investigator, but you will find that he can usually arrive at the same results as either one. An efficient head of a department should have his time free from teaching and research, so that he may keep in touch with college policies; keep the outside world informed of developments within his line of endeavor; study operations, make plans and

improve the system and organization; build the vision and instill the inspiration for the work, and exercise due judgment on all important phases and needs of the department. Any digression from this progress means a definite loss of time and ability of the executive and compels a substitution of minor details for more important work. It is equally true that the executive should keep in touch with all affairs within the department. This can readily be done by a definite knowledge of the system and methods of accomplishments used, reports of results, errors and complaints. Such a program gives the executive a definite point of contact with the workings of the department and the workers. Likewise, it makes each man understand his own importance and offers him a chance for expression.

Many a good scientist has been lost by being forced through circumstances, from his special line of work into the field of administration, where he "does not fit."

Inspiration is a very definite and important element of a successful administration and is most effectively introduced not through speeches, conferences, etc., but through offering the men the opportunity to express themselves in the obtaining of results and in cooperation with co-workers. All workers need encouragement, advice, constructive criticism and pleasant surroundings. To make these possible is the work of the head of the department. Frequent visits to the plantations, classes, laboratories and workshops of each division of a department, with a demonstration of real live interest in the plans and problems of each, makes for success. The chief must be easily approached. Charles Schwab owes his popularity quite largely to his accessibility at any reasonable time. It is usually the big men who are easy to see if one has a mission worthwhile.

Executives are selected largely because of their capacity as organizers. However, it is just as important that the executive possess the ability to deal successfully and amicably with his workers. The personal relation is vitally important in the development of a department. There must be a point of contact, sympathy between workers and a common cause inspiring all to strive for success. Nothing but friendly relationships can destroy the barriers of distrust and hatred and envy. The chief must not only be interested in each man's work, but also in his personal affairs.

The reason for the existence of organization is that it may make smooth the work and improve the output of the product whether it be a piece of machinery, a piece of research, or the instruction of a class of boys and girls. An organization by inspiration should be made to be as good as the best in each of its men instead of as good as the man in authority, and its development should be quickened by the abilities and ideas of all.

People—men and women—form the soul of the department; they imbue the clay with the spark of life. Without them it is nothing and can do nothing. On one side we have the executive; on the other side the organization as a whole including the minor

executives, the rank and file of the personnel through which improvement, betterment, and progress, must be effected. The spirit of cooperation is as important as the method in the handling of the assistants. The positive points of contact between the chief and the assistants determine in a measure the development of the brain power in an organization.

Mr. Edmund J. James, president emeritus of the University of Illinois, tells us in his book, "Sixteen years at the University of Illinois:" "No other feature of the equipment of a University will so largely determine its strength as will the men who are charged with the direct conduct of its various activities. Abundance of land, numerous and spacious builings, well equipped laboratories and libraries and large revenues will not singly or all combined insure for a University either strength or progress. In the final analysis, it is the personnel of the faculty that will chiefly determine the value of the Departments or the University to the commonwealth and its rank among its sister institutions of learning."

Most horticultural departments represent a combination of subjects which have been grouped together mainly for reasons of convenience in administration. Except for this reason, there is no more justification in grouping fruit growing and landscape gardening together than landscape gardening and soil analysis. Most departments are made up of the following units: landscape gardening, pomology, olericulture, floriculture, plant breeding, and extension work. Often nursery methods, forestry, and manufacture of fruit by-products are also included in this department.

It is the business of the department as a unit of the college to concern itself with the large public questions of education, trade, transportation and general betterment, standing for all the horticultural agencies that tend to aid the farmer or the commercial grower to become a more efficient producer. The organization and the administration of an institutional department must cooperate with the trade it represents.

Organization in the department depends upon the diversity of interests. It has been our plan, in the College of Agriculture at the University of Illinois, to develop divisions within the department, headed by able assistants or specialists, to attack in an investigational and instructional way the problems of the various interests, and to attend such meetings as will promote the peculiar line of endeavor. To do this, much executive effort is required on the part of some officer; resulting in the fact that the head of the department no longer can be entirely a productive specialist, but must give a great portion of his time to administering to the affairs of those more or less closely associated with him. Thus the specialist is free to devote the major portion of his time to his specialty, with only a little time required for executive duties. Specialization may go far in research organization, for the more a man narrows the field the deeper he can go, and depth with thoroughness is the quality most desired in investigation. In

teaching, breadth is needed and specialization is apt to go at cross purposes if carried too far. It is not advisable, however, to separate instruction and investigation, as research work enthuses the teacher and he is thereby best able to impress and lead the thought and study of the students.

Let me again emphasize the fact that on the one hand we have the head executive, while on the other the organization as a whole, including the personnel or staff all acting in cooperation to stabilize the organization. I think we are all acquainted with several instances where the department has been torn to pieces because of the loss of the executor, or mainstay, of the organization. Perhaps some of us are acquainted with instances where a department has been virtually sacrificed to promote an individual!

Work is like food. It needs seasoning to become continuously interesting and attractive. It has been my fortunate experience to work with and in an organization where five men have been held in that one department for 16 consecutive years, despite attractive offers from other institutions and the customary storms and stresses of the years. This shows without a doubt, to my mind, that the opportunities have grown with the years to such an extent that it has been worth the while of these men to stay with that particular institution. It also shows a well developed spirit of cooperation.

The spirit is as important as the methods in the building of a department. System, cooperation, understanding, experience, natural ability and training, must be the fundamental elements governing the actions of a group. Very often you will find that personality gets more and better results from workers than force or any other conceivable means of control. The results obtained are the justification of the department. They are the measuring rod of the business. If we are to have a successful department, then we must have good organization and efficient management or administration.

I view with very great alarm the disintegration of so many of our best horticultural departments in this country. The trouble, it seems to me, is due chiefly to the lack of appreciation, in many instances at least, by those in authority of the importance of this very matter which we are now discussing. I wish, therefore, that every one of you would do everything within your power to stabilize and make more effective these horticultural organizations. New heads of departments are being sought for at the University of California, Iowa State College, the University of Missouri, and quite a number of other important institutions. I think it our duty to emphasize at this time the fact that qualities of leadership, wise statesmanship, as well as technical training, are more essential and more a vital factor today than ever before in the development of these institutions. My plea, therefore, is for a stabilization, a standardization, and a unification of our horticultural efforts in the institutions of this country. It is your duty and mine to help one another in the development

of our organizations rather than ruthlessly tearing them down as is the case in so many unfortunate instances at the present time. Let us be interested and progressive in the development of our horticultural science, our teaching, and our extension work, and above everything else, let us not forget that administration is the vital factor in the development of any department of horticulture.

The Effect of Phosphoric Acid on Maturity in Tomatoes

By J. R. Hepler, *Agricultural College, Durham, N. H.*

THE problem of early maturity in tomatoes in the northern states is very important both from the standpoint of price for the early product, and the amount of fruit ripened during the short cool summers. The data presented in this paper were obtained during the season of 1921, which was very warm with an exceptionally late fall so that at least 2 more pickings were obtained than could be had under average conditions.

The plot used had been cropped to hay for a number of years, and was a medium loam with heavy sod of witch grass on it. This soil responds exceptionally well to manure as is shown in the results below, and also in adjoining plots where the yield of field beans in a vegetable rotation was in direct proportion to the amount of manure used, regardless of the application of commercial fertilizers.

The variety of tomatoes used was a strain of Bonny Best which had been bred in the College greenhouses for 8 years. There were 8 separate treatments repeated four times and scattered through the field in such a way as to equalize any differences in soil or drainage. The plots were 20 by 34 feet, but the space of one row between plots was used for a division row so as to prevent the overlapping of fertilizer treatments. There were 32 plants in each plot planted 4 x 4¼ feet, and covering one-eightieth of an acre. Only one of the 1024 plants in the experiment failed to grow and produce a normal crop of fruit. The basic treatment for the plots was 20 tons of manure per acre and was used in plots 2-10-18 -26 as a check treatment. In plots 1-9-17-25, another 20 tons of manure were used making the treatment for these plots 40 tons per acre. In the rest of the plots chemical fertilizers were used as follows:-

Plots 3-11-19-27 1000 pounds acid phosphate per acre.
Plots 4-12-20-28 1000 pounds of gypsum.
(The gypsum was used to determine whether it was the phosphorous or the sulphur in the acid phosphate that affected the yield).

Plots 5-13-21-29 500 pounds acid phosphate.
Plots 6-14-22-30 1000 pounds acid phosphate, 1000 pounds muriate of potash.
Plots 7-15-23-31 1000 pounds of muriate of potash.
Plots 8-16-24-32 1500 pounds acid phosphate.

The soil was acid and was found to require 6000 pounds of lime to correct the acidity. This was applied before planting. The number of fruits and weight of fruit from each plant were recorded separately. Blossom and blossom cluster counts were also made on one-fourth of the plants of each plot.

TABLE I.

Yield of Tomatoes in Pounds Per Acre.

Plot Number	Treatment	Total of 2 Pickings September 1. Weight in pounds and probable error	Total of 2 Pickings September 1. Comparison with check Per cent	Total of 4 Pickings September 13. Weight in pounds and probable error	Total of 4 Pickings September 13. Comparison with check Per cent	Total of 6 Pickings September 26. Weight in pounds and probable error	Total of 6 Pickings September 26. Comparison with check Per cent	Total of 8 Pickings Final record Weight in pounds and probable error	Total of 8 Pickings Final record Comparison with check Per cent	Average Tons Yield Per Plant	Average Tons Yield Per Acre
1- 9-17-24	40 Tons Manure	509± 59.4	77.8	2921± 23.6	116.7	9274±559.6	165.3	37037±2134.7	193.4	14.4	19.5
2-10-18-26	20 Tons Manure (Check)	654± 88.7	100.0	2503±228.5	100.0	5610±507.4	100.0	19148±1769.8	100.0	7.5	9.6
3-11-19-27	20 Tons Manure 1000 pounds Acid Phosphate	690±116.3	105.5	3457±366.4	138.1	9833±820.8	175.3	25291±2039.5	132.1	9.9	12.6
4-12-20-28	20 Tons Manure 1000 pounds Gypsum	490± 57.3	74.9	2849±229.6	113.8	6369±403.6	113.5	23379±1722.6	122.1	9.1	11.7
5-13-21-29	20 Tons Manure 500 pounds Acid Phosphate	555± 42.5	84.8	3053±134.3	122.0	8318±717.0	148.3	29270±1585.7	152.8	11.4	14.6

6-14-22-30	20 Tons Manure 1000 pounds Acid Phosphate 1000 pounds Muriate of Potash	722± 88.7	110.4	3371±199.1	134.6	8889±426.8	158.4	34300±1448.2	179.1	13.4	17.1
7-15-23-31	20 Tons Manure 1000 pounds Muriate of Potash	579± 65.8	88.5	2339±126.8	93.4	5629±175.9	100.3	22078± 646.2	115.1	8.6	11.0
8-16-24-32	20 Tons Manure 1500 pounds Acid Phosphate	680± 64.5	104.0	3537±211.2	141.3	10479±265.4	186.8	34691±1203.3	181.1	13.6	17.3

While the results of the first two pickings were not very decisive, it may be noted that all of the three plots yielding more than the check were phosphorus plots, while only one phosphorous plot was under the check plot in yield.

The total of the first four pickings shows the phosphorous plots 3-5-6 and 8 very definitely in the lead. The effect is still more pronounced in the totals for the first 6 pickings, where the increase in yield is 75 per cent, 48, 58 and 87 per cent respectively in plots 3-5-6 and 8. The extra manure plot with an increase of 65 per cent is third. The sixth picking was made September 26 and would ordinarily mean the last picking of plant ripened fruit. The effects of potash as shown by a comparison of plots 3-6-8 and plots 2 and 7 are very interesting, in that potash apparently has very little influence on yield and delays maturity as plot 6 does not catch up to plot 3 until the last picking, while plots 2 and 7 run very close throughout.

Blossom and blossom cluster counts were made to determine whether the increased yield and earlier maturity from acid phosphate were due to a quicker ripening of the fruit after setting; whether phosphorus treated plants set more fruits per cluster, or whether they produced larger plants with more flowers. An analysis of table 2 shows the latter to be true. There was little difference in the time of ripening of individual fruits after they set. The number of fruits set depended on the number of clusters, and the number of clusters depended largely on the size of the plant. Acid Phosphate stimulated an early growth which produced a greater number of blossoms early in the growth of the plant.

TABLE II.

Total Number of Blossoms on 32 Plants from 4 Plots.

Plot No.	No. of Blossoms 3 counts Aug. 1.	Per cent Comparison with check	No. of Blossoms 5 counts Aug. 10	Per cent Comparison with check	No. of Blossoms 7 counts Sept. 7	Per cent Compared to check	Fruits Set Number	Fruits Set Per cent
1- 9-17-25	1518	163.9	5490	163.4	8325	145.8	2315	27.8
Average per plot	379.5± 38.5	.....	1372.5± 86.4	.....	2081.1± 89.5	.....	....	....
2-10-18-26	926	100.	3360	100.	5710	100.	1530	26.8
Average per plot	231.5± 35.8	.....	840 ± 79.5	.....	1427.5±110.3	.....	....	....
3-11-19-27	1694	182.7	5969	177.6	8280	145.	1913	23.4
Average per plot	423.5± 55.9	.....	1492.2±227.9	.....	2070 ±260	.....	....	....
4-12-20-28	1294	139.7	3872	115.2	5930	103.8	1585	26.5
Average per plot	323.5± 43.6	.....	968 ±134.0	.....	1482.5±126.1	.....	....	....
5-13-21-29	1365	147.4	5152	153.3	7142	125.1	1946	27.2
Average per plot	341.2± 24.2	.....	1288 ±127.9	.....	1793.2±126.4	.....	....	....
6-10-22-30	1904	205.6	6046	179.9	8739	153.	2344	26.8
Average per plot	476 ± 60.3	.....	1511.5±129.3	.....	2184.7±133	.....	....	....
7-15-23-31	1017	109.8	3264	97.1	5698	99.8	1592	27.8
Average per plot	254.2± 34.6	.....	816 ± 59.9	.....	1424.5± 93.5	.....	....	....
8-16-24-32	2038	220.1	6069	180.6	8699	152.3	2347	26.9
Average per plot	509.5± 58.6	.....	1517.2± 83.3	.....	2174.7±138.9	.....	....	....

GREAT PLAINS SECTION OF THE A. S. H. S.

By H. L. Lantz, *Secretary Great Plains Section, Ames, Iowa*

THE fifth annual meeting of the Great Plains Section of the American Society for Horticultural Science was held in Iowa, August 15 to 18, 1922, under the auspices of the Department of Horticulture of Iowa State College.

It was the purpose of the Iowa meeting to provide a well balanced field program that would permit first hand study of fruit breeding material, commercial pomology, commercial nursery production, floriculture, and commercial vegetable gardening.

August 15 was devoted to the dedication of a granite monument to the original Delicious apple tree which still stands in the old orchard planted by the late Jess Hiatt near Peru, Iowa. The granite monument was placed in the public park of the town of Winterset, Iowa, a few miles from the Delicious tree. Official horticulturists from many states and from Canada made a pilgrimage to the old tree and participated in the dedication exercises which were held at Winterset, Madison County, Iowa. Prominent horticulturists who gave papers at the dedication included Professor C. I. Lewis, Paul C. Stark, Prof. C. P. Close. The dedication of a monument to Delicious was made possible through the generous cooperation of the Iowa State Horticultural Society, the Iowa State Historical Department, and the Madison County Historical Society.

The forenoon of August 16 was given over to a formal program at Iowa State College. The afternoon was spent in an inspection trip about the campus, gardens, and the fruit breeding orchards. The party left Ames by auto for Hampton that evening where they remained for the night.

On August 17, the party was the guests of Mr. Earl Ferris, owner of the Ferris Evergreen Nurseries, for a few hours in the morning, who provided a delightful trip through his extensive plantation of evergreens and explained many of the cultural methods which he employs.

The party motored from here to Charles City visiting enroute Mason City, and the Seimer Gladiolas plantation at Nora Springs, and arrived in Charles City for lunch. Immediately after lunch a tour of inspection of the State Fruit Breeding Farm was made. This tract consists of 17 acres and was the old stamping grounds of the late Charles G. Patten, one of the pioneer plant breeders of Iowa who began his work here in 1866. In 1917 this tract, together with its unique and valuable collection of hardy fruit breeding material which Mr. Patten had developed, was purchased and is now being developed by the Pomology Section of Iowa Agricultural Experiment Station.

Several commercial orchards consisting largely of Wealthy were next visited. Following this the Sherman Nursery Company took the party in charge and conducted an instructive tour through

their large evergreen nursery and also through Wildwood Park of Charles City.

August 18 was given over to visiting the Osage and St. Ansgar region lying up the Cedar Valley from 18 to 30 miles northwest of Charles City. At Osage is located the Gardner Nursery which has done a great deal of strawberry breeding work and specializes in new strawberry varieties as well as many other novelties. At St. Ansgar is located one of the most highly developed trucking regions of the Mississippi Valley. Onions, potatoes, cabbage and sugar beets are grown on a very extensive scale.

Generous entertainment in the way of delightful luncheons was provided by local organizations at Wintercst, at Charles City, Osage and St. Ansgar. These given in honor of our visiting horticulturists were greatly appreciated.

The following addresses are the only ones which will be printed in the report.

Address of Prof. W. T. Macoun, Ottawa, Canada

President of the Great Plains Section

I WISH to express on behalf of the members of the Great Plains Section our appreciation of the kind words that have been spoken this morning welcoming us to this College and for all of the information of the great work which is being carried on here in this country. Perhaps there are many here who know little or nothing about this Great Plains Section of the American Society for Horticultural Science.

In the summer of 1918 a number of the official horticulturists of the Northern Great Plains, organized at Mandan, North Dakota Station, with the object of investigating the horticultural problems and the following year we persuaded the members to come to Canada. The next year was spent in Minnesota visiting the College and University and the Fruit Breeding Farm. We thought that it was time for the members to come to eastern Canada in 1921 and we had a number of the members come East and had a most interesting time. Now we are here this year visiting the Iowa State College and other places of interest in Iowa.

At the winter meeting of the American Society for Horticultural Science, a year ago last winter, this was organized as the Great Plains Section of the American Society for Horticultural Science. Now it is a matter of great grief to us that Professor Beach is not here today because he was one who helped organize the American Society for Horticultural Science, in 1903, almost 20 years ago. There are very few here who were at that meeting.

The object of this Great Plains Section is to investigate the problems which confront horticulturists in the colder portions of

America, particularly on the Great Plains. Now we have problems in the north that those who are in warmer parts of America do not have to face, of hardiness due to cold weather. Hardiness in its relation to cold weather—that is the line of investigation to which perhaps this section has paid the greatest attention although not the only one. We have found that the best way to get this information is to go and see what other people are doing. You can read about it, but unless you go and see you cannot get the information in the way which you should. So the method has been to gather at a central place like Ames for our meeting. We have great difficulty in some parts of the North in growing apples at all. We do not have much difficulty in the growing of plums and when it comes to cherries there are not many grown. The small fruits are more easily grown. What we are trying to do is to develop as rapidly as possible the kinds of fruit which will succeed all over the North and be just as good fruits as those that are grown in the southern parts of America. Between central Minnesota and the north pole there are comparatively few commercial apple orchards grown. We have found in our work so far as hardiness of fruit is concerned that you might go 700 miles due north of here and find an apple orchard. There is no reason why you could not have an apple orchard 1500 miles from here so far as latitude is concerned, because we find as we go north the summer temperature is almost the same as that down here but the altitude, we find, is a more important factor than the latitude. The altitude goes down as you go further north. In the latitude 55° and 56° we have grown some tree fruits. The low altitude and the length of day, off-set,to a very great extent, the other conditions. Other conditions than lowness of temperature are serious. Two of the conditions which we find, are that the tree will grow too late in the fall and while the tree is still in a growing condition we may get a temperature down to about zero, and that is very hard on trees which are still growing. Then in the spring just when the trees are starting into growth, we may get a temperature below zero. This Great Plains Section of the American Society for Horticultural Science is international in character. We are all brothers in this section and we are trying to help each other in every possible way we can. We have an Experiment Station at Morden, Manitoba, and the manager of that Station has set it off into sections,—one for South Dakota products, one for Iowa products, for Minnesota, etc., so that we will be able to see how things that originated in Iowa, South Dakota, etc., are succeeding up there. To show how valuable our work here is I may say that in the case of South Dakota I have been all over our Great Plains this season and find several varieties originated in that state succeeding on our pairies. We shall also learn much of value from the fruit breeding farm at Excelsior, Minnesota. Then I would like to mention at this time the work of the late J. L. Budd of this Institution. To those of you who live in Iowa a good many do not think that Professor Budd's work was of very much value to American horticulture.

He was interested in Russian fruits, but while the Russian fruits may not prove of value here they have proven of considerable value in other parts of America. Take the orchard of Mr. A. P. Stevenson of Morden, Manitoba, the varieties of apples he grows are ones that Professor Budd recommended 30 years ago and which Mr. Stevenson planted. I shall mention a few of the hardiest apples. A hardy apple is the Blush Calville which is an early summer apple something like the Yellow Transparent although of softer flesh. The Repka Malenka also known under the name of Beautiful Arcade and Good Peasant, is a sweet apple, yellow, and the tree is extremely hardy. It is early in ripening. We have found in our experience that it is the summer apples which are the hardiest apples. The next apple is the Simbirsk, there are several numbers of them, but Simbirsk numbers one and nine are the best and number one is the hardiest. Anisette is very similar to the Oldenburg, coming from the same family but the Oldenburg has not proven quite so hardy as the Anisette. Then the next apple which I might mention is the Hibernal which is considered the hardiest apple of them all. We have found in growing seedlings of the Hibernal that the seedlings are much more tender than a good many other Russian varieties. After Hibernal are the Charlamoff and Ostrakoff sometimes called Ostrakoff Glass. Those varieties I should say are the hardiest that Mr. Stevenson grows.

Professor J. L. Budd will go down in history as a man who has helped Western Canada in a very marked degree. I say that these Russian apples are very hardy. The altitude is only about 750 feet at Morden whereas when we go further northwest we get an altitude up to 4000 feet and these Russian apples are of no value whatever so that we have to get still hardier ones than those if we will supply every household which we hope to do some day. We imported from the Imeprial Botanical Garden, St. Petersburg, Russia, in 1887, seed of the Siberian Crab apple, Pyrus baccata. We planted it and trees grew which were sent up to our Canadian people along with a very large number of apples both Russian and American. Not one of the latter survived. These Siberian crab apples survived and the trees after 34 years are bearing heavily at Indian Head, Saskatchewan. Dr. Saunders, late director of the Dominion Experiment Farms, was very much interested in the breeding of hardy plants and crossed that hardy crab apple with the apple as we had a few of this crab apple fruiting at Ottawa and many varieties of the Russian apples were crossed on the Pyrus baccata. From that cross were grown many seedlings, but of all the large numbers there were no fruits larger than one and one-half inches in diameter. Now this wild Siberian crab apple ranges from the size of a pea up to a good sized cherry. This first generation was then sent out to our Canadian prairies. After all these years we have just found two of those which we consider hardy in the colder parts of our Canadian prairies. These two have been named the Columbia and Osman. When we had our meeting in Canada in

1920 Dr. Dorsey then of Minnesota, was especially interested in hardiness and his method was to cut the wood of these trees and there were only two trees which had not been injured in some way by frost.

We have a fruit breeding station at Morden, Manitoba, with a large acreage available of which Mr. W. R. Leslie is in charge and we hope within a very short time to get something which will be very valuable to our Canadian northwest. We are working with plums, cherries, etc., but our interest is in the apple more than others.

In regard to the Delicious apple which we saw yesterday. I do not know that I should take up any more time, but I have just come from British Columbia and I find that the Delicious apple is considered by many to be their most profitable apple for although it does not yield so heavily they get more for it. The Delicious apple is an apple which requires lots of heat in order to make it an apple to compare favorably with certain other varieties. We have the McIntosh apple which we consider better than Delicious as it is grown in Eastern Canada. The Delicious needs a hot climate which we get in southwestern Ontario where the Delicious apple will be grown extensively. I consider that Iowa has, so far done her part in the production of new things of merit. The hardy apple, the Delicious apple, and the new apples which are being propagated at this College at Ames. Some of the practical young fruit growers say to us, "Look at the varieties that are grafted today such as the Delicious—they are just chance seedlings, what's the use of you fellows trying to get new varieties." I try to explain that these few good apples that have originated in the past 200 years in America were not originated in a short time but as chance seedlings covering a long period of time, and I would say there is a vast difference in the varieties grown today, as varieties are changing all the time and we who are breeding these new varieties of fruits must keep on working for better success, and the change in the lists of varieties recommended will be much greater in the next 50 years than it has been in the last 100 or more.

Correlations in the Strawberry

By M. B. Davis, *Central Experimental Farm, Ottawa, Canada.*

In growing strawberry plants in the hill system much variation in yield and vigor is noticable. In the matted row large numbers of barren plants are to be found. The causes of these are being sought in a few experiments and the results of these investigations to date might be of interest.

In 1915 a number of strawberry plants were grown individually, but permitted to form stolons and the yields from these hills of stolons were recorded and the ten heaviest and ten poorest

yielding hills were propagated from for the purpose of progeny testing.

In 1918 these progeny fruited, and it was found that there was positive correlation between the yield of the parent and the offspring, which is indicative and suggestive.

The question arose as to whether this could be termed bud heredity, or whether this correlation must be attributed to causes other than those of hèreditary differences isolated by clonal selection.

An explanation of the causes of this correlation in yield of parent and offspring is, of course, the question uppermost in our minds, together with the query as to whether or not by continuous selection of the clone, one can actually maintain a higher yielding strain of plants. If this correlation is due to hereditary factors, it may be possible to isolate a bud sport, or, on the other hand, it may present a parallel case to that in peas and beans where, by continuous selection and reversion to elite stock plots every three years, high yields are maintained. In this latter case sports are evidently not obtained, for by discontinuing selection the progeny reverts to the mean of the variety in question.

Another suggestion as to the cause of this correlation was that there might be a correlation between the age of the stolon when planted and the subsequent yield. Earlier formed stolons with better developed crowns might get a slightly better start than later formed ones and thus always have a bit of a lead over them. To throw light on this point the following experiment was started.

In 1919, a number of Parsons strawberry plants were set out at a distance of five feet apart in rows six feet apart. The runners, or stolons, from each parent plant were kept separate and a record was taken as to the position of each stolon and the date when it first rooted. This was accomplished by staking each stolon as soon as it formed, giving it a serial number and dating it. In this way, at the end of 1919, there was on hand a large number of individual strawberry plants, of which the following was definitely known: (1) date of formation or rooting, (2) parent, (3) position or location with regard to the parent. For example, parent N. 56 put out a runner which rooted on the 14th of July. This plant was given the number 56/1 and the date of its formation, namely 14-7, appended to the label. The 56 in the number of the original plant and the 1 signified that it was the first stolon put out by the original parent. This plant, later on put out a stolon which was designated as 56/11, and 56 itself put out another stolon which received the number 56/2, and so on.

The test was divided into two sections. In one instance all these young plants with known dates of formation and pedigree were lifted and transplanted. In the other instance they were permitted to continue growth in their original location and allowed to fruit, a record being kept of the number of fruits produced by each individual stolon in the matted row.

Results

Dealing first with that part of the experiment where the stolons

were permitted to remain in their original position, it was found that there was decided correlation between the date the stolon rooted and the ultimate number of fruits it produced. Stolons formed as late as the 20th of October produced, on the average, only five fruits, whereas, stolons formed about the middle of August produced an average of 16 fruits. Runners formed much earlier than this produced about nine to ten fruits. Apparently the reason for the falling off of these extremely early formed stolons is due to the fact that these are the parents of large numbers of stolons and, like the original parents, became depleted of energy. The number of these early, poor yielders is comparativly small, as will be seen by examining table No. 1. which shows the percentage of stolons formed on the different dates. From an examination of this table, it is evident that the most profitable period of stolon formation lies between the latter part of July and the first of September. Although over one-third of the stolons were formed in October, they produced only 19.6 per cent of the crop, which, when compared with 34 per cent of the crop produced by 25 per cent of the stolons which were formed in August, demonstrates the great vaue of early planting and good care in the early part of the season.

Summary of Part I of the Experiment

Briefly then it has been shown; (1) that the stolons formed in the early part of the season are the ones which give the largest number of flower stalks and hence the largest yield of fruit, (2) that, athough the stolons produced directly by the original parent (here termed first generation plants) are not in all cases the earliest formed or rooted, they give larger returns than the stolons produced by themselves, etc., or in other words, that there is also correlation between yield and generation. The practical value of this is apparent and is an object lesson that early planting and extra care during the early part of the season are of the utmost value in economic strawberry production.

Part II. of the Experiment

In this phase the pedigree plants were lifted and transplanted and grown in the hill system to determine whether or not there would be an advantage in selecting the largest and best formed stolons, generally found in the centre of the row, in preference to the later formed or smaller ones located on the outer edges of the mat.

Owing to the extremely dry season of 1921, this experiment was not fruitful of results. The heaviest yielding plants, or those plants which bid fair to be the heavy producers, were naturally more affected by the drought than those carrying a small load of berries, consequently the results were hardly comparable. This test has, therefore, been continued and is now being run on two different lines; (1) where the plants are grown as individuals on the hill system, and (2) where they are permitted to form matted rows. The only results to date have demonstrated that the very

late formed stolons were not able to get as early a start as those of larger size. Stolons rooted on 29-10-21 and transplanted in 1922 had, on July 7 of this year, formed less than an average of one stolon per plant; whereas, stolons rooted on 23-7-21, and transplanted at the same time, had on the same date formed 2½ stolons per plant. The advantage of the older stolons is again evidenced, and failing in the attempt by clonal selection to isolate a super-yielding strain, an explanation may here be found as to why, for at least one generation, one can obtain an apparent correlation between the yield of parent and offspring.

Table No. I showing the percentage of stolons formed on different dates

Date		Percentage formed	
July	7	.37	
"	14	1.11	
"	16	.61	
"	18	.74	
"	21	.25	6.76 per cent formed during month of July produced 6.5 per cent of the fruit.
"	23	1.23	
"	26	.12	
"	28	1.11	
"	30	.61	
August	2	.98	
"	6	1.11	
"	8	.25	
"	11	2.21	25.10 per cent formed during month of August produced 34 per cent of the fruit.
"	14	1.11	
"	18	3.08	
"	22	16.36	
September	3	7.13	
"	8	.49	
"	18	16.61	31.36 per cent formed during month of September produced 39 per cent of the fruit.
"	19	.12	
"	20	7.01	
October	10	27.43	39.22 per cent formed during month of October produced 19.6 per cent of the fruit.
"	10 (After)	11.79	

PACIFIC COAST SECTION OF THE A. S. H. S.

THE Pacific Coast Section has not yet been definitely organized, but probably will be in 1923. There is a wonderfully active organization, the Nortwestern Association of Horticulturists, Entomologists and Plant Pathologists, whose membership is composed of officials from California, Oregon, Washington, Idaho, British Columbia and United States Department of Agriculture employees located in the Northwest. It is expected now that the A. S. H. S. members in this association will organize themselves into the Pacific Coast Section, but will probably not segregate themselves or their program from the larger association mentioned above. The papers presented at the general meetings by members of the A. S. H. S. section might be of such nature as to be printed in the annual report of the Society. None of the papers read at the meeting at Yakima, Washington, on July 24, 25, and 26, 1922, have been sent the Secretary for printing in this report. The Secretary attended this meeting on July 25 and found an audience of nearly 200 discussing many phases of fruit and vegetable work. He was impressed with the snap and action put into the meeting.

Business Items

Certification of Nursery Stock

After some discussion on the question of nursery stock certification, a committee was appointed by President Blair to consider this matter and report at the next annual meeting. The committee appointed is J. K. Shaw, Chairman, W. H. Chandler, C. A. McCue, W. T. Macoun and M. A. Blake.

Union of Biological Societies

The Secretary made a report on what had been accomplished during the past year toward the organization of a Union of Biological Societies, and suggested that the Society become a charter member of this union and that the President and Secretary represent the Society in the union during 1923. The Society adopted this suggestion.

Annual Reports for Russian Scientists

A request for annual reports to be donated to the Russian scientists was discussed and it was voted that the Secretary should send six copies of each of the recent annual reports with the compliments of the Society.

Inter-Society Committee on Crown Gall

Several of the scientific societies are much exercised over the question of crown gall, and have asked for a committee composed of one member of each society to study this disease during the year and report at the 1923 meeting. Dr. M. J. Dorsey was appointed to represent our Society.

Amendment to Constitution

The Secretary offered an amendment to the Constitution as follows:—That in the first line of Article V the words "three Vice-Presidents" be changed to read "a Vice-President." The amendment will be voted on at the next annual meeting.

Report of Nominating Committee

The nominating committee consisting of Messrs. Auchter, Gardner, Brock, Wellington and Macoun, reported the names of J. H. Gourley and Paul Work as candidates for president, and the other officers and committees as given on Page 5 of this report. The balloting for president resulted in the election of J. H. Gourley

National Botanical Garden and Arboretum

The Washington Botanical Garden will eventually be moved from its present site near the Capitol Building, and the Washington Chapter of the Wild Flower Preservation Society has appealed to other societies to lend their support toward a movement to induce Congress to appropriate sufficient funds to establish the National Botanical Garden and Arboretum on a permanent site with land enough for all time, 2,000 acres finally. A committee consisting of C. A. McCue, W. S. Brown, and Paul Work, was appointed to report on the matter; this the committee did in the following resolution which was unanimously adopted,—

Resolved, that the American Society for Horticultural Science express itself in favor of the movement for the establishment and support of a National Botanical Garden and Arboretum by Congressional appropriation or appropriations; and

Be it further resolved that this Society approve of the general plans for such Botanical Garden promulgated by the Wild Flower Preservation Society, Washington Chapter; and

Be it further resolved that this Society appropriate a sum of fifteen dollars toward defraying the expenses of a publicity campaign to influence public sentiment toward the need of a National Botanical Garden and Arboretum.

C. A. McCue,
W. S. Brown,
Paul Work,
Committee.

Report of the Committee on Resolutions

Resolved that the American Society for Horticultural Science extend to the Massachusetts Institute of Technology its appreciation for the use of buildings for this meeting and also for the lantern and other equipment kindly furnished:—

Also, be it resolved that the Society express to the Secretary its appreciation of the efficient and timely method with which he has handled all matters pertaining to the interests of the Society keeping it in a healthy and growing condition.

R. A. Van Meter
J. H. Gourley,
W. T. Macoun,
Committee.

Dinner and Social Hour

SIXTY-FOUR members and friends sat down to a good dinned at the Copley Square Hotel after which we adjourned to another room for our social evening. To eliminate any formality and to extend acquaintance among the members, the President asked each one to stand up and give his name and the name of his institution.

The Society suffered the loss of five members during 1922 and the social evening was set aside to pay tribute to these men. Three of these men, namely, Beach, Tracy and Whitten, were charter members of the Society, Stewart joined in 1907, and Sprague in 1922.

Prof. Waugh gave a very interesting account of the life and work of Prof. S. A. Beach. Others who spoke on Prof. Beach were Blair, Macoun, Close, Holland and Tukey. Close read some items from the early records of the organization of the Society in Boston in 1903, these naturally referred to Beach who conceived and pushed the organization of the Society. Holland told of Beach's last years of work and the tribute paid to him at Iowa State College. Tukey read a copy of the resolutions prepared and adopted by Beach's associates at the Iowa State College.

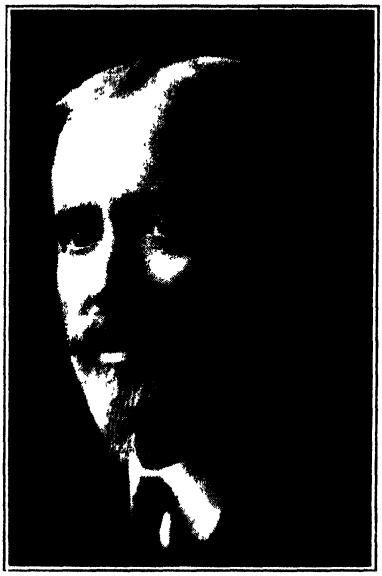
Dr. Chandler told of the life and accomplishments of Dr. J. C. Whitten with whom he had been very intimately associated for several years. Others who spoke of Dr. Whitten were Blair, Shaw, Farout, Woodbury, Heinicke and Oskamp, and Brock read a beautiful tribute to him written by Dean F. B. Mumford with whom he was associated for 23 years at the University of Missouri.

Dr. W. W. Tracy was one of the older men who seldom attended the annual meetings and was known to but few of the younger men. Prof. Crandle was associated with him 50 years ago at the Michigan Agricultural College and gave an entertaining account of his college activities and later work. Thompson and Close spoke of his many and valuable contributions to the science of horticulture.

Dr. John P. Stewart was taken before he reached the prime of life. Prof. Anthony sketched briefly his life and valuable pomological work in Pennsylvania. Blair, Myers and Close spoke of their very intimate relations with Stewart in professional and civil life.

Mr. T. O. Sprague joined the Society this year and very few members knew him. Wellington who has associated with him for a few months at Geneva gave a brief account of him.

The evening ended with a story telling contest between McCue, McHatton, and other entertaining extemporaneous speakers. The members considered this an evening well spent.



JOHN CHARLES WHITTEN

Obituary

John Charles Whitten

DOCTOR John Charles Whitten, Professor of Pomology and Chief of the Division of Pomology, University of California, died in Washington, D. C. on June 5, 1922. He had gone to Washington to attend the Washington Plant Quarantine Conference at the request of the Secretary of Agriculture, and during this conference became ill and died of meningitis.

Dr. Whitten was born in Augusta, Maine, September 14, 1866, being the son of Albert and Viola Whitten. He was educated in the public schools of Augusta, Maine, and Brookings, S. D., South Dakota Agricultural College; Cornell University; Missouri Botanical Gardens, and the University of Halle. He was a Bachelor of Science and Master of Science of South Dakota and a Ph. D. of the University of Halle-Whittenberg. In 1892, he was an instructor in Horticulture and Horticulturist of the Experiment Station at Brookings, South Dakota; was assistant in Horticulture at the Missouri Botanical Gardens, St. Louis, 1893 and 1894. Professor of Horticulture and Horticulturist of the Missouri Agricultural Experiment Station, 1894 to 1918, and Professor of Pomology, University of California, from 1918 to the time of his death. In 1902 and 1903 he was President of the Missouri State Horticultural Society. He was a member of the St. Louis Academy of Science; the American Association for the Promotion of Agricultural Science; the American Pomological Society; the American Society for Horticultural Science, and numerous honorary and social organizations. He was the author of many bulletins and pamphlets published by the Missouri Experiment Station and hundreds of papers in horticultural publications and scientific societies.

Although the writer was associated with Dr. Whitten as student and colleague for 19 years, he cannot do better than quote in part from a recent tribute from the pen of Dean F. B. Mumford of the University of Missouri, who was associated with him from the time he went to Missouri in 1895 until he went to California in 1918.

"Dr. Whitten was a great teacher. Probably no man who has ever been associated with the College of Agriculture of the University of Missouri, was so popular as a teacher. He never lost his fine zeal and enthusiasm. His knowledge of the horticulture of the state and of the subject in its broader phases was remarkable. In particular did he come to know all the problems, difficulties, opportunities for success, and conditions of failure in the fruit growing sections of the State of Missouri. His advice and counsel were sought by everyone—students and fruit growers alike.

"The University of Missouri and the horticulture of the State owe much to John C. Whitten. He was in continuous service at the institution for 23 years. During that time he became a leading figure among the horticultural experts in America. Because of his great fame he was invited by the University of California to assume the leadership of the Department of Horticulture in that institution, located in a state where horticulture is the predominating enterprise. The same qualities which made him so successful in Missouri rapidly gained for him great distinction in the Golden State."

W. L. Howard.

Spencer Ambrose Beach

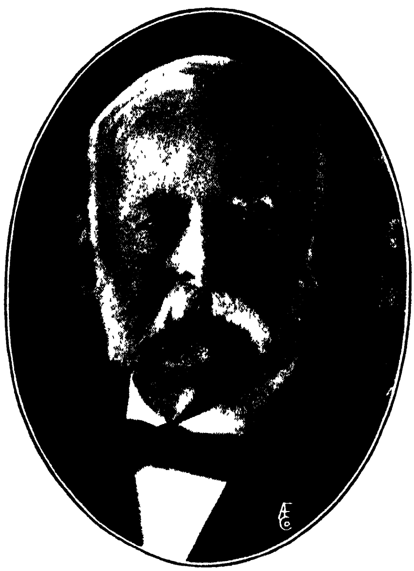
Professor Beach died at Ames, November 2, 1922. He was born at Sumner Hill, Cayuga County, New York in 1860, graduated at the Iowa State College in 1887. In 1890 he married his classmate, Miss Norma Hainer, who survives him with three sons, Frank H. of the Horticultural Department of Ohio State University; Julius E. in law practice in Chicago; and Victor H. who was graduated at Iowa State College last June. Directly after graduation Professor Beach became associated with the Silas Wilson Nursery at Atlantic, Iowa, leaving there to become the head of the Department of Horticulture at the Texas College of Agriculture. He left Texas to become the Horticulturist of the Geneva New York Experiment Station. During the 14 years at Geneva he was very successful as an investigator showing much originality and vision in his work Here were written many valuable bulletins, and especially his great work "The Apples of New York" in two volumes, which stands out as a model of thorough work. It has been well termed "a monumental work."

Beach was of old New England Puritan ancestry tracing back to pre-Revolutionary days. This Puritan ancestry was in full evidence all his life, giving him patience and accuracy in recording details, and also a fine deeply religious bent and social vision which ensured him the right cooperation from his associates on the campus and outside. At the World's Fair at St. Louis in 1904, Beach asked my advice as to his accepting the offer just made to come to Iowa State College at Ames as Chief of Horticulture. Knowing the fine work Beach had done with grapes, apples and other fruits at Geneva, I was certain that he had the necessary equipment for this new work. We had studied together under J. L. Budd at Ames, and I urged upon Beach very strongly that he should accept the offer. I assured him he would find friendship and cooperation here in the West. I was glad to learn that Beach accepted the offer and came to Ames in 1905. Of his work at Geneva a leading New York horticulturist said: "Professor Beach's work put fruit growing in the lake region of New York on a successful commercial basis." I need not here give in detail Beach's great work in building up the present splendid department at Ames, that is a part of the horticultural history of the West. Noteworthy is his generous action in having Iowa take over as the state fruit-breeding farm the Charles G. Patten orchard and fruit-breeding plantations at Charles City, thereby saving the lifetime of work on the part of Mr. Patten.

Beach began apple breeding work on a large scale, and the collection of original apple breeding material aggregates nearly 3000 trees of bearing age and upwards of 30,000 seedlings. At the Midwest Horticultural Show at Council Bluffs, Iowa, there was a wonderful exhibit of their new apples. Beach has really built his own monument in these seedlings.

Finally, as a classmate and friend of Professor Beach, I grieve at his passing. It is a loss for all of us. But I rejoice that he was able to do much good work in a lifetime. It is an inspiration for the young men coming on. N. E. Hansen

SPENCER AMBROSE BEACH



DR. WILLIAM WARNER TRACY

DR. WILLIAM WARNER TRACY

Dr. William Warner Tracy was born at Hudson, Ohio, May 21, 1845, and died in Washington, D. C., March 1, 1922. His parents moved to Windsor, Vermont, about 1850, and to Andover, Massachusetts, about 1854. He enlisted in Company D, 45th Massachusetts Infantry, September 12, 1862, at the age of 17. He was discharged September 2, 1863, after being invalided home with a wound received in the battle of New Bern, North Carolina. He entered the Michigan Agricutural College in 1864, and graduated with the degree of B. S. in 1867. He studied with Asa Gray for a time and took his Master's Degree at the Michigan Agricultural College in 1870, and in 1907 this College conferred upon him the honorary degree of Doctor of Science.

He was Professor of Horticulture at his Alma Mater in 1870--1872. In 1873, he moved to Old Mission on Grand Travers Peninsula in Michigan. Here he planted an orchard of apples and pears which is still in bearing. At this place he grew a crop of seed peas for D. M. Ferry & Company, and after this introduction received an offer to develop the testing and stock seed farm of this firm. He took up this work in 1879 and gave 24 years to it, then entered the United States Department of Agriculture in 1903, and retired from active work April 23, 1921. From this time to his death he lived with his son J. E. W. Tracy.

As a boy at Andover he often busied himself in planting trees in places where he thought the landscape should be improved. Many of these trees are still standing. His work on stocks of vegetables with D. M. Ferry & Company, and later on the trial grounds of the United States Department of Agriculture, gave him a wide acquaintance and reputation and the opportunity to meet many younger men whom he influenced very strongly.

He did not write extensively, having published a book on tomato culture and several bulletins on seed subjects. His ability to inspire through conversation was very great, however, and most men will remember him mainly from his talks in the trial grounds, the office, on the train, or wherever he met anyone interested in plants.

He had a very quick preception of slight differences in stocks of plants and aways asked searching questions as to any practical use the variation might have, either directly, or as a correlated indicator, for other characters of greater value.

He was much interested in clearing up the tangle of vegetable variety names and had devised a series of descriptive cards which are widely used and which give definiteness and uniformity to varietal description.

Dr. Tracy was decended from a long line of New England ancestry and added a very attractive personality to the traditional New England virtues of a sterner sort.

D. N. SHOEMAKER

Dr. John Pogue Stewart

Dr. John Pogue Stewart was born on a farm in Illinois in 1876. From the State Normal School, he entered the University of Illinois and graduated in 1902 with the degree of B. S. The following year he took his Master's degree in Agriculture at Cornell. During his college years he had specialized in chemistry and botany and on completing his work at Cornell he went to the Illinois State Normal School to teach botany and nature study.

In 1907 a department of Experimental Pomology was established at The Pennsylvania State College and John Pogue Stewart was chosen to head this new work. Fifteen years ago the field of research in pomology was almost virgin ground and Stewart threw himself into this new work with an enthusiasm and energy that soon made him a leader among the fruit growers of the State and among his fellow research workers.

Soon after his work in Pennsylvania was well started he went back to Cornell for further study under John Craig, and in 1911 received the degree of Ph. D., taking for his doctorate the subject of fertilization of orchards. This and the question of methods of orchard management were the two main lines of study which he undertook in Pennsylvania.

In 1917 he resigned from his position at State College to take up commercial fruit growing in Pennsylvania. It was while superintending some of the work on one of his farms in January, 1922, that he contracted the cold which resulted in his death five days later from pneumonia. While caring for him in his last illness his wife also contracted pneumonia and survived him by only a few days.

Dr. Stewart was a prolific writer and from 1910 to 1920, the reports of the Pennsylvania State Horticultural Association, the annual reports and bulletins of the State College, and the volumes of the American Society for Horticultural Science, contain many articles from him. His two outstanding contributions in the field of research were to show the importance of nitrogen in the sod orchard and the inter-relation of orchard management methods and methods of fertilization. He also did much in introducing the lime-sulfur spray.

"J. P." as he was known to his fellow workers, was a member of Alpha Zeta, Gamma Alpha, and Sigma Xi.

R. D. Anthony.

JOHN POGUE STEWART

THOMAS O. SPRAGUE

Thomas O. Sprague was born in Paris, France, August 3, 1896. His father R. H. Sprague, a successful American business man, resided at Mento Park, California, when Thomas O. Sprague was taking collegiate work. In 1919 he graduated from the University of California and the same fall entered Cornell University for graduate work in horticulture. In 1920 he took up duties as assistant in research (horticulture) at the N. Y. Agricultural Experiment Station, Geneva, N. Y. On December 31, 1921 he resigned on account of ill health and shortly after started home via Panama Canal. Before the boat reached the canal the Captain reported that Sprague had been lost overboard.

Thomas O. Sprague possessed a quiet, retiring and unassuming nature. He talked very little about his private affairs and never had a complaint or an ill word to say about anyone. His character and personality were truly lovable.

He was undoubtedly an excellent student. As an assistant in research he did excellent work. He was very conscientious, studious and painstaking and possessed a deep interest in horticulture. Horticulture has certainly lost a promising man, and those of us who knew him a true friend.

R. WELLINGTON

Membership Roll for 1922*

ALDERMAN, W. H. .....University Farm, St. Paul. Minn.
ALLEN, F. W. ....University Farm, Davis, Calif.
ANDERSON, J. P. ....Juneau, Alaska,
ANDERSON, O. G. ....Purdue University, Lafayette, Ind.
ANGELO, ERNEST ....West Virginia University, Morgantown, W. Va.
ANTHONY, R. D. ....Experiment Station, State College, Pa.
AUCHTER, E. C. ....University of Maryland, College Park, Md.
AUST, F. A. ....University of Wisconsin, Madison, Wis.
AXT, R. W. ....University of Illinois, Urbana, Ill.

BABCOCK, E. B. ....University of California, Berkeley, Calif.
BAILEY, L. H. ....Ithaca, N. Y.
BAIRD, W. P ....Northern Great Plains Field Station, Mandan, N. D.
BALCH, W. B. ....Agricultural College, Manhattan, Kans.
BALLARD, W. R. ....University of Maryland, College Park, Md.
BARNETT, R. J. ....Agricultural College, Manhattan, Kans.
BARRON, LEONARD ......Garden City, N. Y.
BARSS, A. F. ....University of British Columbia, Vancouver, B. C.
BATCHELER, L. D........Citrus Experiment Station, Riverside, Calif.
BEACH, F. H. ....Ohio State University, Columbus, Ohio.
BEAL, A. C. ....Cornell University, Ithaca, N. Y.
BEATTIE, J. H. ....U. S. Dept. Agr., Washington, D. C.
BEATTIE, W R. ....U. S. Dept. Agr., Washington, D. C.
BEAUMONT, J. H. ......University Farm, St. Paul Minn.
BIERBAUM, E. A. ....Missouri Fruit Experiment Station, Mountain Grove, Mo.
BENNETT, J. P. ....University of California, Berkeley, Calif
BIOLETTI, F. T. .... University of California, Berkeley, Calif
BLAIR, J. C. ....University of Illinois, Urbana, Ill.
BLAIR, W. S. ....Experiment Station, Kentville, Nova Scotia.
BLAKE, M. A. ....Experiment Station, New Brunswick, N. J.
BLOOD, P. T. .. . Agricultural College, Durham, N. H.
BOWDITCH, E. D. .... Experiment Station, Raleigh, N. C.
BRADFORD, F. C.........Agricultural College, East Lansing, Mich.
BRIERLEY, W. G. ......University Farm, St. Paul. Minn.
BROCK, W. S...........University of Illinois, Urbana, Ill.
BROWN, H. D. ....Purdue University, Lafayette. Ind.
BROWN W. S. ....Agricultural College, Corvallis, Ore.
BUCK, F. E. ....University of British Columbia, Vancouver, B. C.
BUNTING, T. G. . .... Macdonald College, Macdonald College, Quebec, Can.
BURKHOLDER, C L. .....Purdue University, Lafayette, Ind.
BURROWS A. M. ....University of Missouri, Columbia, Mo.
BUSHNELL, J. W. ....University Farm, St. Paul. Minn.

CADY, LEROY ....University Farm, St. Paul. Minn.
CALDWELL, J. S. ....U. S. Dept. Agr., Washington, D. C.
CARDINELL, H. A. ......Agricultural College, East Lansing, Mich.
CARRICK, D. B ....Cornell University, Ithaca, N. Y.
CHANDLER, W. H ......Cornell University, Ithaca, N. Y.
CLARK, C. F. ....U. S. Dept. Agr., Washington, D. C.
CLARK, F. R. . ...Experiment Station, Geneva, N. Y.
CLARK, J. H. ....Delaware College, Newark, Del.
CLEMENT, F. M. ....University of British Columbia, Vancouver, B. C.
CLOSE, C. P. ....U. S. Dept. Agr., Washington, D. C.
COIT, J. E. ....1880 Linda Vista Ave., Pasadena, Calif.
COLBY, A. S. ....University of Illinois, Champaign, Ill.
COLE, W. R. ....Agricultural College, Amherst, Mass.
CONDIT, I. J. ....California Peach and Fig Growers Association, Fresno. Calif.
CONNORS, C. H. ....Experiment Station, New Brunswick, N. J.

* See obituary for deceased members.

COOPER, J. R. ....University of Arkansas, Fayetteville, Arkansas.
CORBETT, L. C. ....U. S. Dept. Agr., Washington, D. C.
CRANDALL, C. S. ......University of Illinois, Urbana, Ill.
CRANE, H. L. ....University of West Virginia, Morgantown, W. Va.
CROW, J. W. ....Simcoe, Ontario, Canada.
CRUESS, W. V. ....University of California, Berkeley, Calif.
CRUICKSHANK, R. B. ...Ohio State University, Columbus, Ohio.
CULLINAN, F. P. ....Purdue University, Lafayette, Indiana.
CUMMINGS, M. B. ......Experiment Station, Burlington, Vt.
CUNNINGHAM, J. C. ....Dominion Experimental Farm, Frederickton, N. B.

DACY, A. L. ....Massachusetts Agricultural College, Amherst, Mass.
DANIELS, F. P. ....University Farm, St. Paul. Minn.
DARROW, G. M. ....U. S. Dept. Agr., Washington, D. C.
DARROW, W. H ....Agricultural College, Storrs, Conn.
DAVIS, M. B. ....Dominion Experimental Farm, Ottawa, Canada
DAVIS, V. H. ....State Department of Agriculture, Columbus, Ohio.
DEARING, CHARLES .....Willard, N. C.
DETJEN, L. R. ....Delaware College, Newark, Del.
DICKENS, ALBERT ......Agricultural College, Manhattan, Kans.
DICKSON, G. F. ....Vineland Station, Ontario, Can.
DIKEMAN, R. C. ....Cornell University, Ithaca, N. Y.
DORNER, H. B. ....University of Illinois, Champaign, Ill.
DORSEY, M. J. ....West Virginia University, Morgantown, W. Va.
DRAIN, B. D. ....Massachusetts Agricultural College, Amherst, Mass.
DRINKARD, JR., A. W. ...Experiment Station, Blacksburg, Va.
DUDLEY, F. H. ....5 Manitou Ave., Poughkeepsie, N. Y.
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J. H. GOURLEY

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NOMINATING COMMITTEE

M. A. Blake, *Chairman*
R. E. Marshall
R. J. Barnett
J. K. Shaw
C. S. Crandall

PROGRAM COMMITTEE

E. C. Auchter, *Chairman*
H. B. Tukey
C. P. Close
F. C. Sears
E. F. Palmer
J. T. Rosa, Jr.
N. E. Hansen

SECTIONAL GROUPS AND MEMBERSHIP

R. D. Anthony
S. P. Hollister
T. H. McHatton
E. M. Harvey
W. R. Leslie
L. D. Batchelor
E. J. Kyle

BOTANICAL ABSTRACTS

J. W. Bushnell
V. R. Gardner

A. A. A. S. COUNCIL

C. P. Close

NATIONAL RESEARCH COUNCIL

H. D. Hooker, Jr.
U. P. Hedrick
J. R. Magness
T. C. Johnson
C. P. Close

CONSTITUTION*

ARTICLE I

The name of this Association shall be the American Society for Horticultural Science.

ARTICLE II

The object of the Society shall be to promote the Science of Horticulture.

ARTICLE III

Any person who has a baccalaureate degree and holds an official position in an agricultural college, experiment station, or Federal or state department of agriculture in the United States or Canada, is eligible to membership. Other applicants may be admitted by vote of the executive committee.

ARTICLE IV

Meetings shall be held annually at such time and place as may be designated by the Executive Committee, unless otherwise ordered by the Society.

ARTICLE V

The officers shall consist of a President, a Vice-President, and a Secretary-Treasurer, who, together with the chairmen of the standing committees shall constitute a Council to act upon all applications for membership. There shall also be an assistant Secretary. These officers shall be elected annually by ballot.

ARTICLE VI

This Constitution may be amended by two-thirds votes of the Society at any regular meeting, notice of such amendment having been read at the last regular meeting.

BY-LAWS

SECTION 1. The President and other officers shall perform the usual duties of their respective offices. The President shall also deliver an address at each regular meeting.

SECTION 2. There shall be a Committee on Nominations consisting of five (5) members, who shall be nominated and elected by ballot at each regular meeting of the Society. It shall be the duty of this committee, at the following meeting, to suggest to the Society names for officers, referees, and members of committees for the ensuing year.†

SECTION 3. There shall be an Executive Committee, consisting of three (3) members and the President and the Secretary, ex-officio. This committee shall perform the usual duties devolving upon such committee.

SECTION 4. The Committee on Nominations shall nominate referees and alternates upon special subjects of investigation or instruction, which may be referred to its consideration by the Society. The duties of these referees shall be to make concise reports upon recent investigations or methods of teaching in the subjects assigned them, and to report the present status of the same.

SECTION 5. There shall be a Committee on Program, consisting of seven (7) members of which the Secretary shall be one. This committee shall have charge of the scientific activities of the Society, except as otherwise ordered by the Society.

SECTION 6. The annual dues of the Society shall be two dollars and fifty cents.

SECTION 7. Ten members of the Society shall constitute a quorum.

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*The Constitution and By-Laws as amended from time to time.
†Since 1918 two lists of candidates have been required.

TREASURER'S REPORT FOR 1923

VOUCH-ER NO.	1923		CR.		
	Jan.	1	Expenses of Secretary Close in attending Boston meeting		$2.60
	Jan.	3	Stamps		1.00
(1)	Jan.	3	R. E. Marshall, East Lansing, Mich.—300 two-cent stamps		6.00
	Jan.	6	Stamps		1.00
	Jan.	6	Telegram on December 1, 1922, to Boston, Mass.		.93
	Jan.	6	Two telegrams to Boston, Mass, December 13, 1922,		1.69
	Jan.	16	Stamps		1.00
	Jan.	6	Telegram to J. C. Blair, Urbana, Ill.		.81
	Jan.	27	Stamps		1.00
	Feb.	1	Stamps		1.00
	Feb.	6	Telegram to J. K. Shaw, Amherst, Mass.		.53
	Feb.	10	Telegram to J. K. Shaw, Amherst, Mass.		.53
	Feb.	10	Stamps		1.00
	Feb.	13	Stamps		1.00
	Feb.	28	Stamps		1.00
(2)	Feb.	28	The Telegraph Printing Co., Harrisburg, Pa.		
			1500 letter heads	$8.50	
			Postage	.22	
			1700 envelopes	9.50	
			Postage	.17	
					18.39
(3)	Mar.	7	Chas. G. Stott & Co., Inc., Washington, D. C. 700 Columbia Clasp envelopes		12.50
	Mar.	16	Stamps		1.00
(4)	Mar.	20	Express on reports from Harrisburg, Pa.		1.19
	Mar.	23	Stamps		1.00
	Mar.	28	Stamps		2.00
(5)	Apr.	2	The Telegraph Printing Co., Harrisburg, Pa.		
			425 reports for 1922—279 pages and cover at $2.05 per page	$580.15	
			4 inserts at $3.25 each	13.00	
			4 half-tone cuts at $3.75 each	15.00	
			Mailing and postage	41.25	
				$649.40	
			Less over-charge on inserts	3.25	
					$646.15
	Apr.	4	Stamps		4.00
	Apr.	17	Stamps		1.00
	Apr.	30	Stamps		1.00
	May	8	Stamps		1.00
	May	17	Stamps		1.00
	June	6	Stamps		1.00
	Oct.	1	Stamps		1.00
	Oct.	9	Stamps		3.00
	Nov.	1	Stamps		1.00
	Nov.	3	Stamps		1.00
	Nov.	12	Stamps		1.00
(6)	Nov.	23	Donation for National Botanical Garden and Arboretum voted at the 1922 Annual meeting		15.00
	Nov.	30	Stamps		1.00
	Dec.	8	Stamps		5.00
	Dec.	8	Stamps		1.00
	Dec.	13	Stamps		1.00
	Dec.	24	Stamps		2.00
	Dec.	29	To Balance		$648.52
	Total				$1,392.85

1923		Dr.	
Jan.	1	By Balance	$351.84
Jan.	2	University Farm, Davis, Calif., reports 1911, 1920, 1921	6.00
Jan.	6	Department of Agriculture, Athens, Ontario, Canada, report 1921	2.50
Jan.	27	A. M. Sprenger, Wageningen, Holland, reports 1920, 1921	5.00
Feb.	10	F. W. Faxon Company, Boston, Mass., report 1922	2.50
Feb.	16	W. H. Nixon, San Carlos, Calif., report 1920	2.50
Feb.	17	Missouri Botanical Garden, St. Louis, Mo., reports 1914 to 1921, inclusive	13.00
Feb.	21	His Majesty's Stationery Office, London, England, reports 1920, 1921	5.00
Mar.	15	H. W. Clark, Muscatine, Iowa, report 1922	2.50
Mar.	22	His Majesty's Stationery Office, London, England, reports 1916 to 1921, inclusive	11.00
Mar.	30	F. W. Faxon Company, Boston, Mass., 2 reports for 1922	5.00
Apr.	6	Ontario Agricultural College, Guelph, Ontario, Canada, reports 1905 to 1921, inclusive except those for 1907 and 1911	19.00
Apr.	16	Missouri Botanical Garden, St. Louis, Mo., report 1922	2.50
Apr.	16	Experiment Station, Blacksburg, Va., report for 1922	2.50
Apr.	17	State College of Washington, Pullman, Wash., Report 1922	2.50
Apr.	17	Cornell University, Ithaca, N. Y., report 1922	2.50
Apr.	23	Experiment Station, Experiment, Ga., report 1922	2.50
Apr.	24	Massachusetts Horticultural Society, Boston, Mass., report 1922	2.50
Apr.	24	University of Vermont, Burlington, Vt., report 1922	2.50
Apr.	24	University of Maine, Orono, Me., report 1922	2.50
Apr.	24	Experiment Station, Lexington, Ky., report 1922	2.50
Apr.	24	Arnold Arboretum, Jamaica Plain, Mass., report 1922	2.50
Apr.	26	New Jersey Experiment Station, New Brunswick, N. J., 5 reports for 1921	12.50
Apr.	26	Oregon Agricultural College, Corvallis, Oregon, report 1922	2.50
Apr.	30	Lincinio Cappili, Bologna, Italy, reports 1905, 1906, 1908 & 9, 1910, 1912, 1913, 1914, 1915, 1922	10.50
Apr.	30	Brooklyn Botanic Garden, Brooklyn, N. Y., report 1922	2.50
Apr.	30	A. M. Sprenger, Wageningen, Holland, report 1922	2.50
Apr.	30	Paul C. Stark, Louisana, Mo., reports 1919, 1920, 1921, 1922	9.00
May	2	Seattle Public Library, Seattle, Wash., report 1922	2.50
May	3	Stanford University, Stanford University P. O., Calif., report 1922	2.50
May	4	Southern Oregon Experiment Station, Talent, Ore., report 1922	2.50
May	7	University of Minnesota, St. Paul, Minn., report 1922	2.50
May	8	Georgia State College of Agriculture, Athens, Ga., reports 1921, 1922	5.00
May	8	Utah Agricultural College, Logan, Utah, report 1922	2.50
May	23	Massachusetts Agricultural College, Amherst, Mass., report 1922	2.50
May	23	Thorburn & Abbott, Ottawa, Canada, report 1922	2.50
May	24	University of Wisconsin, Madison, Wis., report 1922	2.50
May	25	University of Missouri, Columbia, Mo., reports 1916, 1922	3.50
May	31	Iowa State College, Ames, Iowa, report 1922	2.50
May	31	University of California, Berkeley, Calif., 2 reports for 1922	5.00
June	1	University of California, Berkeley, Calif., report for 1922	2.50
June	1	Niels Esbjerg, Blangsted, Denmark, reports 1921, 1922	5.00
June	2	University of Nebraska, Lincoln Neb., report 1922	2.50
June	5	H. B. Holcombe, Nashville, Tenn., report 1922	2.50

July 16	Dr. R. Florin, Akademiens Axperimental Faltet, Sweden, reports 1912, 1917, 1919, 1920, 1921	9.00
July 19	G. E. Stechert & Company, New York City, report 1922	2.50
Aug. 27	Dr. R. Florin, Akademiens Axperimental Faltet, Sweden, reports 1922, 1913, 1915, 1916	6.00
Sept. 25	Wheldon & Wesley, Ltd., London, England, reports 1921, 1922	5.00
Sept. 25	Macdonald College, Macdonald College P. O., Quebec, Canada, reports 1917, 1918, 1919, 1920, 1921	9.50
Sept. 29	Roy Larsen, Wenatchee, Wash., report 1922	2.50
Sept. 22	The Chemical Catalogue Co., Inc., New York City, report 1921	2.50
Oct. 1	University of Minnesota, St. Paul, Minn., report 1917	1.50
Oct. 31	W. H. Nixon, San Carlos, Calif., reports 1921, 1922 ...	5.00
Nov. 10	P. L. Keene, Brookings, S. D., reports 1905, 1906, 1908 & 9, 1910, ...	4.00
Dec. 6	J. H. Lavoie, Quebec, Canada, report 1922	2.50
Dec. 6	Royal Veterinary and Agricultural College, Copenhagen, Denmark, reports 1921, 1922	5.00
Dec. 18	L. C. Schermerhorn, New Brunswick, N. J., reports 1920, 1921, 1922	6.50
Dec. 22	Norwegian Fruit Experiment Station, Harmansverk, Norway, reports 1921, 1922	5.00
Dec. 24	Arthur F. Bird, London, England, reports 1921, 1922	5.00
	Dues collected since last meeting	784.50
	Total	$1,392.84

Respectfully submitted,

C. P. Close, *Treasurer.*

The Auditing Committee reported that it had examined the accounts of the Treasurer and found them to be correct.

M. J. Dorsey,
W. H. Alderman,
L. Greene,
Auditing Committee.

ANNUAL MEETING AT CINCINNATI, OHIO

December 27, 28, and 29, 1923

The twentieth annual meeting in Cincinnati opened with the usual vim and the crowded program kept things moving at a rapid pace. At times interest waned somewhat for two reasons: (1) Some of the speakers illustrated their addresses with chalk talks and forgot all about their time limit, and (2) during the first half of the meeting the papers of absent authors were read, thus the personal element was lacking. While reading these papers is desirable when time will permit, it does take some of the time which might well be used for discussion of the papers read by authors.

With the mass of material now offered for the program each year, it will be quite necessary for the chairman to warn each speaker about two minutes before his time is up, and then adhere strictly to the time limit, unless the Society votes an extension of time to the speaker. By doing this we will get back to the snap and ring of the Chicago meeting in 1920 which stands out as the very best of all the exceedingly good meetings the Society has yet held.

President Gourley presided at all of the sessions except when occasionally calling some other member to the chair. The attendance was about the same as at the Boston meeting last year. There were probably 85 members present during the course of the meeting. Seventy-five members partook of the Society dinner on the evening of December 28th.

Next year a register will be kept of all who attend the Washington meeting and their names will each be marked by a star in the membership roll in the annual report. This done annually will add interest as a history of attendance in the years to come.

Cost of Apple Production in Minnesota*

BY W. G. BRIERLEY, *University of Minnesota, St. Paul, Minn.*

WHILE the State of Minnesota does not figure largely in the apple production of the country as a whole, its annual production averages around 1,250,000 bushels of which 300,000 bushels may be considered commercial production. The question has arisen frequently if the commercial apple grower in Minnesota is able to make a profit in the enterprise and meet the strong competition from other sections. With this question in mind a study of production costs by the survey method was completed

*Published with the approval of the Director as Paper No. 433 of the Journal Series of the Minnesota Agricultural Experiment Station.

in 1920, covering the years 1916 to 1920. Paralleling the cost study, observations were made in regard to general orchard conditions.

Most of the orchards in Minnesota are found in the neighborhood of Lake Minnetonka, along the Mississippi Valley or in the southern tier of counties. Although the 1920 census shows 13,000 acres of bearing orchard, most of this acreage is in home orchards and not over 2,000 acres can be considered in commercial production. The majority of these orchards were planted from 1900 to 1906.

The standards of management are not high. A few are well managed, but the majority border upon neglect, or show marked defects in treatment. Most of the orchards are badly crowded, the average population being 122 trees per acre. Pruning is not done thoroughly, spraying is rather poorly done due to lack of good equipment, or to too few applications. Most orchards are in old sod and are making poor growth. A gradual improvement is being made in the management of these orchards, but it should be noted here that the averages given are made from data obtained in orchards which have not had proper management. If good management were the rule, there is no doubt that yields and returns would be increased considerably at little extra cost.

On the average, the prices for local apples has equalled or exceeded the prices for those shipped from other sections. The Minnesota grower is favored by an apparent inversion of competition which seems to prevail in regions producing only a small proportion of the apples used in that section. The great bulk of apples consumed in Minnesota comes from the large producing centers such as Washington, Michigan, and Missouri. The selling price for these apples is the price at the point of origin plus transportation and handling charges. The local grower having much lower transportation costs finds a favorable price maintained which yields him a wider margin of net profit than his competitors receive. Granting that this survey covering the years 1916 to 1920 includes three years of high prices, it must not be overlooked that little grading is done in Minnesota and that for poorly graded fruit the price will range lower than for a well graded product. The average price for all grades during the period covered by the survey was $1.53 per bushel. Including culls, practically all of which are sold, the price averaged $1.44.

Data were obtained from only 64 orchards, but these are representative of the industry. Each orchard was visited and the figures obtained on the basis of normal operations based on a five year average. The earlier records were supplemented by additional data bringing all up to the basis of 1920. All data departing markedly from the normal have been disregarded in striking the weighted averages.

In the orchards surveyed there were 487 acres of bearing trees representing 33.9 per cent of the tillable land of the farms. The average acre valuation was $510.00. The average orchard comprised 7.6 acres the range in size being from 1.2 to 30 acres. The age ranged from 8 to 36 years, but averaged 16 years in 1920.

As pointed out previously the orchards are badly crowded averaging 122 trees per acre. Under such conditions the bearing wood is confined to the upper third of the trees resulting in the low average yield of 1.2 bushels per tree and 150 bushels per acre. In the better managed orchards the yields ranged from 250 to 400 bushels indicating the possibilities under good care.

The leading commercial varieties are Wealthy, Oldenburg, Northwestern Greening, and Patten (Greening). Other varieties such as Hibernal, Salome, Wolf River, Malinda, Anisim, and Charlamoff, are found frequently. McIntosh, Delicious, Grimes, King David and other more tender varieties are occasionally found top-worked on hardy stock.

The average gross returns based on the yields and prices already given amounted to $215.99 per acre, ranging from $24.00 in a poor orchard to $506.00 in the best one. In 28 of the better grade of orchards the gross amounted to $307.00 per acre. This last figure clearly indicates the value of better management and shows the possibilities of the Minnesota orchard.

Common maintenance practices are manuring, pruning, brush disposal, spraying and mowing. The labor and cost charges for these items are given in the accompanying table. The figures for spraying are based on two applications per year. At the time of the survey a few were spraying three or four times, but the majority sprayed only twice. During the past two or three years there has been much improvement in this item in the way of greater efficiency and more applications.

Handling items include picking, hauling from the orchard, sorting and packing, and hauling to market. Not much sorting or grading is done except the removal of culls. The average haul to market is 2.25 miles and the average load 58 bushels.

Total labor charges average 131.7 man hours per acre of which 56.3 hours are credited to the owner. Horse hours average 55.3. Labor has been charged at the average rate for farm labor of 25 cents per man hour and 15 cents per horse hour. Labor costs average $41.24 per acre and 27.7 cents per bushel.

Material costs, including the charges for spray materials, manure, packages and replacement of picking baskets, amount to $42.15 per acre and 28.2 cents per bushel. The package charge is the largest single item of cost as seen in the table, and is an average of the prices of baskets and barrels prevailing during the period covered in the survey. The manure charge is for 3.7 tons per acre at $1.50 per ton. The spray materials used in two applications of 125 gallons per acre were 7.5 pounds of arsenate of lead and 6.25 gallons of lime-sulfur concentrate. The average price of the lead arsenate was 27 cents per pound and the lime-sulfur averaged 25 cents per gallon.

Fixed costs amount to $38.17 per acre and 25.3 cents per bushel. Interest on the investment of $510.00 per acre is charged at 6 per cent. Taxes are charged arbitrarily at .5 per cent of the investment. Spray equipment valuation averaged $18.24 per acre. Interest on this amount is charged at 6 per cent and depreciation at 12.5 per cent. Miscellaneous equipment valuation averaged

$10.33 per acre. Interest on this amount is charged at 6 per cent and depreciation at 10 per cent.

The total operating costs amount to $121.56 per acre and 81.2 cents per bushel. Overhead is fixed arbitrarily at 3 per cent of these figures and amount to $3.64 per acre and 2.4 cents per bushel.

Total costs as seen in the table are $125.20 per acre and 83.6 cents per bushel. With gross returns of $215.99 and 144.3 cents per acre and per bushel respectively, the net return amounts to $90.79 per acre and 60.7 cents per bushel. In 28 of the better orchards the gross returns averaged $307.81 per acre leaving a larger net profit although costs were somewhat above the average.

The average total income per acre includes the owners labor value of $14.09, interest charges of $32.31, and the net profit of $90.79 totalling $137.19 per acre. Though based on data from rather poorly handled orchards, these figures indicate that apple orcharding can be made to pay well in Minesota. The industry probably never will become extensively developed, but with good management and suitable varieties, it certainly can be conducted profitably.

SUMMARY OF ACRE AND BUSHEL COSTS AND PROFITS IN MINNESOTA APPLE ORCHARDS

	Man Hours per Acre	Horse Hours per Acre	Cost per Acre in Dollars	Cost per Bushel in Cents
Manuring	6.96	11.54	$3.47	2.3
Pruning	17.83	.....	4.46	2.9
Disposal of brush	3.54	3.55	1.42	0.9
Spraying (2 times)	16.46	11.24	5.80	3.8
Mowing grass	6.17	4.07	2.15	1.4
Total maintenance costs	50.96	30.4	17.30	11.3
Picking	50.31	.....	12.58	8.4
Hauling from orchard	9.02	12.41	4.12	2.7
Sorting and packing	14.32	.....	3.58	2.6
Hauling to market	7.14	12.52	3.66	2.7
Total handling costs	80.79	24.93	23.94	16.4
Total labor costs	131.75	55.33	41.24	27.7
Spray materials	......	.....	5.61	3.7
Manure	......	.....	3.58	2.4
Packages	......	.....	32.04	21.5
Replacement of picking baskets	......	.....	0.92	0.6
Total material costs	......	.....	42.15	28.2
Interest on investment	......	.....	30.60	20.4
Taxes	......	.....	2.55	1.7
Spray equipment—interest	......	.....	1.09	0.7
Spray equipment—depreciation	......	.....	2.28	1.5
Miscellaneous equipment—interest	......	.....	0.62	0.4
Miscellaneous equipment—depreciation	......	.....	1.03	0.6
Total fixed costs	......	.....	38.17	25.3
Total operating costs	......	.....	121.56	81.2
Overhead (3 per cent of operating costs)	......	.....	3.64	2.4
Total costs	......	.....	125.20	83.6
			Per Acre	Per Bushel
Gross returns	......	.....	215.99	144.3
			Per Acre	Per Bushel
Net profit	......	.....	90.79	60.7

Oldenburg as Female in Apple Crosses

By C. S. Crandall, *University of Illinois, Urbana, Ill.*

OLDENBURG is one of 50 varieties that have been used in the breeding work at the Illinois Station during the past 15 years. Flowers of Oldenburg were pollinated and fruits matured in eight of the 15 years and seedlings from these crosses now range in age from six to 14 years. There were 24 crosses representing 20 different parental combinations, involving 805 pollinations and maturing 284 fruits. Ten of the pollen parents were orchard varieties and 10 were crablike forms of the apple genus. Thirteen of the crosses were made on trees in orchard and 11 on dwarf trees in pots in the greenhouse.

Six of the 24 attempted crosses failed; one in orchard and five in the greenhouse; together they involved 86 pollinations. The success percentage for the 24 crosses is 35.27, or considering only the 18 fruit producing crosses, it is 39.49. Pollinations made in orchard gave a higher percentage of success than did those made in the greenhouse, and pollinations by pollen from orchard varieties were more successful than pollinations by pollen from the crablike forms.

Greenhouse crosses deal with small numbers because the trees used are small, often producing but few clusters of flowers. For this Oldenburg group the average of pollinations for the orchard crosses was 58 and for the greenhouse crosses 16.

For all crosses attempted in 14 years using 50 orchard varieties and 47 crab-like forms, approximately 24 per cent of the pollinations were successful in fruit production. The percentage for this Oldenburg group is, as stated, 35.27. This is considerably above the percentage for all crosses, and, while not the highest for individual groups, it deserves rank as a reasonably high degree of success in fruit production. Examples of groups attaining higher success are found in Rome Beauty, which, with 1240 pollinations in 22 crosses none of which failed completely, produced 496 fruits, or 40 per cent of the pollinations successful; Longfield in 7 crosses had 360 pollinations, 38 per cent of which produced fruits. Among the crab forms, Malus baccata oblonga which served as the female in 8 crosses with 197 pollinations, developed 152 fruits, or 77.15 per cent of the pollinations successful, and one form of Malus prunifolia (838) with 22 crosses and only one complete failure, had 60 per cent of the 1089 pollinations successful.

As examples of low success percentages I may cite Ben Davis which served as female in 16 crosses with only 10 per cent of the 999 pollinations successful; Domine 17 crosses with less than five per cent of the 616 pollinations successful; Fameuse with 625 pollinations in 19 crosses and only nine per cent successful, and Winesap with 35 crosses in which 1011 pollinations yielded only 28 fruits, or 2.76 per cent of the pollinations successful.

Thus the variety Oldenburg stands fairly high in the matter

of percentage of successful pollinations. Of course percentage of fruit matured from any group of pollinations does not determine the degree of success that may attach to the cross; there are other things just as important that must be taken into consideration before the value of a particular combination of parents can be established. Fruits produced may be seedless, seeds may not germinate, seedlings may be too weak to live or prove utterly worthless if brought to fruiting.

In support of the statement that degree of success of a cross is not determined by percentage of fruit producing pollinations, I may refer to the experience with Malus Ioensis. This species was used as the female parent in six crosses involving 469 pollinations which yielded 181 fruits, or 38.59 per cent of the pollinations successful in fruit production. There were six seeds to each fruit and 45 per cent of the seeds germinated. But the seedlings had no vitality, they were uniformly weak and died more or less promptly. Of 469 seedlings produced, 448 or 95.52 per cent are now dead. Only 21 survive and it is a safe prediction that none will live to fruiting. Results were the same with Malus Soulardi and the Mercer County crab. I regard these forms as useless for breeding material, but, of course, there is always the chance that a combination may be discovered giving different and better results.

Seed production by fruits of Oldenburg crosses is reasonably good. For the various crosses the averages range from two to each fruit for the cross by one of the crab forms (19667) to 7.65 seeds to each fruit for the cross by Malus baccata (806). The average for all fruits of all crosses is 6.06 and may be considered a fair average.

Germination ranged from 16⅔ per cent for one of the crosses by Malus Ringo (840), to 93⅓ per cent for the cross by Malus microcarpa; the average for all crosses is 58 per cent. Of 13 other groups of crosses examined nine have higher average seed germination and four have lower. The average for the 14 groups is 68 per cent. Germination is thus below the average for similar groups and may be rated as no better than fair.

Seedlings from the various crosses are vigorous, although none exhibit that excessive vigor that sometimes characterizes the progeny of crosses. That very weak seedlings were absent from most crosses is shown by the fact that of the 18 fruit producing crosses, 11 sustained no losses of seedlings in the initial stage of existence—the period between appearance above ground and shifting to nursery. Of the 996 seedlings appearing above ground, 953 were transferred to nursery. Forty-three from seven crosses in numbers from two to 17 died because too weak to live. The maximum loss—17, was from the cross by Summer Pound Royal. Other losses were seven from each of the two crosses by Fanny and Malus Malus fl. pl. (833); five from the cross by Malus prunifolia (838); three from the Rome Beauty cross, and two each from the crosses by Twenty Ounce and Ben Davis. For the first year in nursery 11 of the groups sustained no losses and for seven of the groups there was a loss of 66 seedlings in numbers ranging from one each for the Rome Beauty and Malus microcarpa (19644) groups, to 29 for the

Fanny group. This brings the losses for all groups to a little less than seven per cent at the end of the first year and ends the losses that may be directly ascribed to constitutional weakness.

Losses through accidents and disease occurred later in life in 13 of the crossed groups, but five groups came to the end of the record with no losses after the first year. The seedlings from these crosses have grown with reasonable vigor and now those of the earlier crosses are symmetrical, well-formed trees. Ninety per cent of them grade as "good," eight per cent as "fair," and two per cent as "poor."

Most trees resemble Oldenburg in habit; branches are ascending, the younger trees nearly erect, the older with round tops with a tendency to become somewhat spreading. There are individuals that depart somewhat from the prevailing type, but in general tree habit within a group is uniform. There are differences in groups that may be ascribed to differences in male parents; thus the group having Yellow Transparent as the male parent has less spreading trees than have the groups for which Hall No. 6 is the male parent. Hall No. 6 is naturally of more spreading habit than is Yellow Transparent and this tendency to spread finds expression in the progeny. Comparing the two groups of seedlings it appears that the Yellow Transparent group has an average height that exceeds the average spread by about 25 per cent, while in the group having Hall No. 6 as the male parent about eight per cent must be added to the height to make it equal the spread.

Four groups of seedlings are from crosses made in 1909, they are now 14 years old and most of them are established in fruit production. The male parents of the four groups are Domine, represented by six of 10 trees planted; Twenty Ounce represented by 49 of 57 trees planted; Yellow Transparent represented by 73 of 93 trees planted; and Hall No. 6 represented by 81 of 113 trees planted. Of 273 trees planted in the four groups, 209 are living at 14 years of age and of these 193, or a little over 92 per cent, have fruited.

Of the six trees of the cross Oldenburg X Domine, two produced fruits for the first time in 1918 at 9 years of age, one fruited in 1921 at 12 years, and one in 1922 at 13 years. The other two produced each a few blossoms in 1922, but have matured no fruits. Three of the four trees bore fruits of large size and one fruits of small size. In form, all trees bore oblate fruits. There was general resemblance to Oldenburg in fruits from two trees; to Domine in fruits from one tree; fruits from the other tree were unlike those of either parent. One matured fruits in early August, two in late August, and one in mid-September. In general, fruits from trees of this cross are unattractive and mediocre in quality; none are to be propagated and there is no desire to repeat the cross.

The cross Oldenburg X Twenty Ounce is represented by 49 seedlings, all symmetrical, vigorous trees with leaves of large type. Fruits have been described from 46 of the trees of this group; two others have flowered sparingly, but did not mature fruit, and one has, as yet, shown no disposition to flower. Fruits of 31 trees are of large size, some of them very large, and 15 trees have fruits of

medium size; 39 trees have oblate fruits, and seven round fruits. In color they vary widely; 31 have fruits that are more or less striped; fruits from two trees are blushed bright red over yellow, one red over green; seven have self yellow fruits, and five self green fruits. The Oldenburg parentage is evident in fruits from 31 trees, two trees have fruits much like Twenty Ounce, and 13 trees have fruits totally unlike either parent. Grading the fruit as to quality, one tree is rated as best, 24 as good, 18 as fair, and three as poor. As to season of ripening, 10 mature fruit in early August, 20 in mid-August, 15 in late August, and one in early September. Regarding age at which trees began fruiting; two produced their first fruits at seven years, two at eight years, 16 at nine years, two at 11 years, four at 12 years, nine at 13 years, and 11 at 14 years.

Seven of the 46 trees bore fruit of such excellence that they are held worthy of preservation, have been propagated, and when these trees are established in fruit production final judgment may be passed as to whether any of the selections are worthy of being named and distributed.

The cross Oldenburg X Yellow Transparent has 73 living seedlings, 70 of which have fruited. As to size of fruit produced, these trees divide as 30 large, 32 medium, and eight small. In form, fruits from 49 trees are oblate, from 20 trees round, and from one oblong. In color, 44 trees have fruits striped red on yellow, 19 have self yellow fruits, and seven self green fruits. In quality, fruits from the 70 seedlings classify as 29 good, 39 fair, and two poor.

There is distinct resemblance to Oldenburg in fruits from 39 trees; to Yellow Transparent in fruits from 19 trees, and 12 trees have fruits wholly unlike those of either parent. Maturity dates range from early July to late August with the large majority maturing the last days of July and the early days of August. Nine trees bore fruits in 1916 when seven years old, two in 1917 at eight years, 22 in 1918 at nine years, four in 1920 at 11 years, eight in 1921 at 12 years, 15 in 1922 at 13 years, and 10 in 1923 at 14 years. Seven trees have been propagated as worthy of preservation; five of these have color and form characters of Yellow Transparent, and two those of Oldenburg.

The other cross made in 1909 is Oldenburg X Hall No. 6 and is represented by 81 seedlings, 73 of which have borne fruit. The male parent of this cross, so far as I know, has never been named, nor do I know that it has ever been distributed. It was sent to the Station, with others, for trial some 25 or more years ago. The fruit is of medium size, attractive, of dessert quality, and matures in early winter.

Of the 73 seedlings of this cross that have fruited, 30 bore fruits of large size, 38 fruits of medium size, and five bore small fruits. The shape is oblate in 63, round in five, oblong in three, and conical in two. Fruits from 56 trees display red color in varying amounts. In fruits from five trees it is blushed on over yellow, and in fruits from 51 trees it is striped; sometimes as in Oldenburg, but often quite unlike and varying greatly in breadth of stripes, area covered, and intensity of color. Fruits from 12 seedlings are

self yellow, and from five self green. Quality has been rated as "best" for one tree, "good" for 38 trees, "fair" for 30, and "poor" for 4 trees. Greater or less resemblance to the female parent —Oldenburg—is seen in fruits from 33 trees; only two trees have fruits bearing marked resemblance to the male parent, and 38 trees have fruits that, in appearance, do not suggest either parent.

Season of fruit maturity ranges from late July to mid-September with the larger number maturing about the middle of August. Eight trees fruited in 1916 at seven years, one in 1917 at eight years, 32 in 1918 at nine years, one in 1919, three in 1920, one in 1921, 21 in 1922, and six in 1923 at 14 years. Eight of the 73 trees have been propagated for preservation.

The next cross, in point of time, is Oldenburg X Shackleford made in 1911. In this cross 73 per cent of the pollinations were successful, the fruits averaged 6.28 seeds and 69 per cent of the seeds germinated. The seedlings are now 12 years old and 126 or 82.89 per cent of the 152 produced are living; they grade as 110 "good," 15 "fair," and only one "poor"; they are vigorous, somewhat spreading, average 14½ feet in height, 13¼ feet in spread, and 4½ inches in trunk diameter; they grow in contiguous rows and present a symmetrical and fairly uniform appearance.

A little more than half, 66 of the 126, have fruited. Classified as to size of fruit, 34 produce large fruits, 30 fruits of medium size, and two bear small fruits. In form, 50 trees have oblate fruits, 15 round fruits, and one has a distinctly conical fruit. Red color appears in fruits from 53 of the trees; 46 of these are striped in a variety of ways; in seven the red appears as a blush which varied greatly in area covered and in intensity of color. The remaining 13 trees represented among those that have fruited bear yellow fruits that vary from clear light yellow to dull orange. Considered as to quality, fruits of 24 trees rank as good, 30 as fair, and 12 as poor. Only one tree has been deemed of sufficient excellence to warrant propagation; this produced an oblate yellow apple of medium size ripening the last of August and it is preserved because of its possibilities as a dessert fruit. It has firm, crisp flesh with sufficient acidity and a distinctive flavor that is all its own.

Only three trees produce fruits that resemble Shackleford, the male parent; 29 resemble the female parent—Oldenburg—and 34 bear no resemblance to either parent. Season of ripening ranges from late July to early October. Three are recorded as ripening in late July, six in early August, 21 in mid-August, 32 in late August, three in early September, and one in early October. As to age at which fruiting began, one fruited in 1919 at eight years, 12 in 1921 at 10 years, 13 in 1922 at 11 years, and 40 in 1923 at 12 years.

There are still 60 trees in the group that have not borne fruit. Among the trees fruited there are many whose fruits are large and handsome in appearance, but they are, in general, deficient in quality; fruits lack acidity, many are so near neutral that they are tasteless and no matter how strongly they appeal to the eye, if they do not appeal to the palate they are of little economic use.

Six other groups in this lot of Oldenburg crosses include 325

trees and have fruiting record from 71 or nearly 22 per cent of the trees. There remain seven groups with 80 trees, none of which have yet fruited; one of these is from a cross of 1914, one from a cross of 1915, four from crosses of 1916, and one from a 1917 cross.

The 11 groups of seedlings from which fruits have been described contain 660 trees, half of which have fruited. Nine of the groups have orchard varieties as male parents and two have crab-forms as male parents. Fruits from the trees having crabs as male parents are all crab-like and there is nothing in their appearance suggesting resemblance to parents.

In the nine groups which have orchard varieties as male parents, resemblance to parents is apparent in fruits from some trees and is found in one or more of the four characters, size, form, color, or flavor. Having in mind only these four characters, the 286 trees that have produced fruits divide as follows: from 147 trees (51.4 per cent) the fruits resemble Oldenburg, the female parent; from 33 trees (11.54 per cent) the fruits resemble the male parent, and from 106 trees (37.06 per cent) the fruits bear no resemblance to those of either parent. There are, of course, differences between cross-groups as to the frequency with which Oldenburg characters appear with such distinctness that resemblance to the variety is clear; thus while approximately 44 per cent of the seedlings of the Shackleford cross have fruits more or less closely resembling Oldenburg, in the Twenty Ounce cross more than 67 per cent have that resemblance. Regarding resemblance to the male parent; fruits from less than three per cent of the trees from the cross by Hall No. 6 show resemblance to the male parent, while nearly 43 per cent of trees of the Summer Pound Royal bear evident likeness to the male parent. Numbers in this latter cross, however, are small, only seven trees, four of which have fruits resembling Oldenburg and three fruits resembling Summer Pound Royal.

Oldenburg is a good breeder and an agreeable variety to work with whether used as male or female. Flower buds are large, stamens are not closely appressed to styles and emasculation is easy. As male it supplies a high grade pollen in ample quantity. Because of these characteristics the variety has been used, perhaps, more than any other. Oldenburg takes kindly to dwarfing on paradise and has been one of the most dependable varieties in the greenhouse where its pollen has been freely used on first generation hybrids from crosses in which Oldenburg was one of the parents.

As male, Oldenburg has been used in 16 crosses on 14 orchard varieties and in 60 crosses on 32 crab-forms; these crosses involved 5427 pollinations; there were 25 failures and 51 of the crosses matured 1092 fruits which represent 20.12 per cent of the total pollinations.

As first generation seedlings reach flowering maturity, the flowers they bear are pollinated by pollen from one or the other of the parents of the hybrid, and pollen from these hybrids is used on flowers of parents. In this move for a second generation, Oldenburg flowers have been pollinated with pollen from six hybrids; three of the crosses failed and three were more or less successful, producing 27 fruits representing 39.70 per cent of the pollinations.

From these fruits there are now in orchard 35 second generation hybrids five and six years old. Pollen of Oldenburg has been used on 101 hybrids in 143 crosses; 83 in the greenhouse and 60 in the orchard. The total of flowers pollinated is 2532; there were 56 failures and from 87 crosses 546 fruits were matured; from these fruits there are 1517 second generation seedlings living at ages of one to six years.

The Set of Apples as Affected By Some Treatments Given Shortly Before and After the Flowers Open

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THE experiments described in this paper were planned to throw addtional light on the significance of the carbohydrate-nitrogen ratio, and the importance of the water supply as factors in the abscission of normally formed flowers and young fruits of apple.

THE SET OF FRUIT AS AFFECTED BY RINGING OF THE FLOWER-BEARING BRANCH

With the exception of the variety Arkansas, the trees furnishing the material for this study were growing in sod orchards, and they would be classed as moderately to poorly vegetative. All had a good bloom in 1920 and again in 1923, the years in which the experiment was conducted. Just before the flowers opened, in each tree several limbs, approximately three inches in diameter at the point of origin, were ringed near their base by the removal of a band of bark one-half inch wide. Paraffin was applied to the wounds to prevent drying of the sap wood.

TABLE I

Effect of Ringing on the Set of Apples

Lot and Variety	No treatment		Ringed when flowers open	
	Number Flower Spurs	Percentage with fruit	Number Flower Spurs	Percentage with fruit
1. Rhode Island Greening ..	357	33.9	334	41.5
2. Rhode Island Greening ..	340	33.8	343	44.8
3. Rhode Island Greening ..	212	33.5	275	40.8
4. Baldwin	76	61.4	95	82.0
5. Northern Spy	76	50.0	77	80.5
6. Northern Spy	75	30.0	67	94.0
7. Ben Davis	146	43.1	136	99.3
8. Ben Davis	126	27.0	115	74.8
9. Arkansas	208	12.5	197	32.0
10. Arkansas	118	11.9	145	46.2
11. Early Strawberry	364	34.9	230	63.5
12. Sweet Bough	260	20.4	216	44.9
13. Unknown	200	7.5	171	42.6

For each ringed branch a similar untreated branch was designated as a check. The total number of flower bearing spurs and the number producing one or more fruits, was recorded at the end of the season for all limbs.

As indicated by the data in Table I, ringing has invariably increased the set of fruits. The results were even more striking than shown, because spurs on the treated limbs frequently held from two to four fruits. For example, in the case of Ben Davis, the average number of apples on fruitful spurs of treated limbs was 2.2, while spurs on the untreated limbs held an average of only 1.4 apples. The large increase in the percentage of flowers that set fruit in the unknown variety is especially interesting, because this tree was decidedly spurry and under-vegetative. The variety Arkansas which normally shows a poor set, was growing in a cultivated orchard and it was the most vigorous of the trees in this experiment.

It has been demonstrated repeatedly that ringing results in an accumulation of carbohydrates. The fact that such accumulation occurs within a short time even though much of the leaf surface, and especially that on secondary growth arising from the cluster base is still enlarging, is indicated by the more brilliant color of petals that expand a few days after ringing is done. According to some recent work by Dr. O. F. Curtis of the Department of Plant Physiology at Cornell, nitrogen does not pass to tissues above an unhealed ring in the bark in the case of the apple. This is in accordance with results previously obtained with peaches and lilac. (Curtis 1923). Kraybill (1923) working with the apple likewise reports a reduction in nitrogen in the tissue above the wound during the first few weeks after ringing is done. It is reasonable to assume, therefore, that in these experiments the better set of flowers on the ringed limbs was accompanied by an increase in the absolute and also in the relative amount of carbohydrate material.

According to Kraus and Kraybill (1923) a marked abscission of the fruits of the tomato occurs when the carbohydrate content is relatively very high. Murneek (1921) finds the $\frac{C}{N}$ ratio in the composition of defoliated apple spurs, which tend to shed most of their fruits, relative high as compared with normal, fruiting spurs. Were the trees used in our ringing experiments possibly a little too vegetatively even though they apparently showed only moderate vigor so that theoretically they would require the balancing and stabilizing influence of carbohydrates for the highest percentage set? The treatments described in the next section should afford an answer to this question.

The Set of Fruit as Affected by the Application of Nitrate Compared with the Effect of Ringing on the Same Trees

In early spring after the buds had opened, but before the flowers appeared, one side of each of a number of trees received an application of 10 pounds of sodium nitrate. Some of the same trees described in the previous section, or others of similar vigor, were

treated in this way. Auchter (1923) and others have shown that nitrates will go primarily to limbs which are in most direct communication with the roots to which the fertilizer was applied. In several trees so fertilized, one or more branches three inches in diameter at the point of origin, were ringed in the manner already described. This was done before the fertilizer was applied. Some of the ringed branches arose from limbs that were to receive nitrate, and some from limbs on the unfertilized side of the tree. For every treated branch, a comparable unringed branch was designated as a check. The numbers of spurs producing flowers, and those holding one or more fruits, were recorded at the end of the season.

TABLE II

Effect of Ringing and Nitrate Fertilizer on the Set of Apple

Lot and Variety	No treatment		Nitrogen applied		Ringed	
	Number Flower Spurs	Percent with fruit	Number Flower Spurs	Percent with fruit	Number Flower Spurs	Percent with fruit
1. Northern Spy	75	30.0	56	80.4	@ 67	94.0
2. Northern Spy	76	50.0	...	....	77	80.5
3. Northern Spy	...	....	54	88.9	@ 63	92.0
4. Ben Davis	126	27.0	102	54.0	@115	74.8
5. Arkansas	118	11.9	169	37.8	145	46.2
6. Arkansas	208	12.5	183	33.9	197	32.0
7. Rhode Island Greening	212	33.5	...	....	275	40.8
8. Rhode Island Greening	...	....	210	47.5	@228	45.2

@ Ringed branches originate from limbs receiving nitrogen.

It is evident from the data in Table No. II that in any given tree an increased set of apples resulted from both ringing and the application of nitrates. The more vigorous spurs were the more fruitful regardless of the treatment. The set of fruit was also noticeably increased by the fertilizer in the trees that had no ringed branches and which are not recorded in the table. Previous studies have shown that trees in grass are usually deficient in nitrogen, and it is well established (Lewis and Allen 1914) that under such nutrient conditions the application of this element may increase the percentage of flowers that remain on the tree to form fruit. Since most of the trees in our experiment were growing in sod, this characteristic response to the addition of nitrogen was therefore to be expected in the majority of cases.

But the presence of additional nitrogen can hardly account for the increased set found on the ringed limbs, if it be true as already intimated that the removal of the band of bark inhibits the movement of this element to tissues above the wound. Nitrogenous compounds of organic nature would of course not pass below the ring. At least the minimum amount of nitrogen that is probably essential for the setting of large numbers of fruits was evidently present, even in the most poorly vegetative of the trees used in our experiment. Whether or not this is invariably true

in trees that had enough of nitrogen to form flowers remains an open question.

The behavior of the variety Arkansas indicates that even vigorous trees growing in cultivated orchards may respond to spring applications of nitrogen by an increased set of flowers. Other varieties, such as Rhode Island Greening, that are inclined to set poorly even in the absence of grass, may likewise show marked benefits from early spring applications of nitrogen. However, most varieties in cultivated orchards in New York seem not to require this treatment in order to bring about a satisfactory set of fruit. An increased set in response to nitrate application in such cases could be established only by careful counts, since the total yield is determined not only by the number of apples, but also by the size which is apt to be smaller when there are too many fruits.

Attempts to influence the set of apples adversely by excessive applications of nitrogen to the flower-bearing tree have been unsuccessful. As much as 25 pounds of sodium nitrate applied in early spring to one side of 12 year old apple trees growing in a cultivated orchard at Ithaca, has had no detrimental influence on the set. Without a chemical analysis of the tissue itself, it is of course impossible to tell how much nitrogen was actually present in the cluster base, but evidently there is little danger in the case of the heavier soil types of getting too much of this element so far as the set of flowers is concerned. (A much lighter application to trees on sandy soil often results in burning the foliage.) It is questionable whether the set is ever reduced by any treatment or condition that results in the most vigorous vegetative growth that may possibly accompany the opening of normal flowers. To be sure, some of the treatments that are necessary to cause such vigorous growth, as for example excessive pruning, could easily result in a smaller crop on account of the reduced bearing surface, but as has been previously demonstrated the percentage of flowers that set fruit even under these conditions is nevertheless increased. (Heinicke 1917.) There can be little doubt that heavy pruning and the spring application of nitrogen tends to increase the proportion of nitrogenous substances, while the tendency of ringing would be to increase the carbohydrates relatively as well as absolutely. Since the percentage of flowers that remains on the spurs in trees of given moderate vigor is increased by all these treatments, it follows that the range of the $\frac{C}{N}$ ratio that may accompany a good set of fruit in the apple is indeed wide.

The Set of Fruit as Influenced by the Cutting of the Sap Wood

Previous results have indicated that the partial cutting of the sap wood tends to reduce the set of flowers. Such treatment which also necessitates an injury to the bark would affect the composition of the sap as well as reduce the water supply to the tissues above the girdle. In the present series of experi-

ments, an attempt was made to minimize the injury to the phloem so as to emphasize the disturbed water relationship. This was accomplished by carefully removing from three inch limbs a band of bark one-fourth inch wide; the sap wood was then cut by sawing entirely around the branch to a depth of one-half to three-quarters of an inch. After this, the band was immediately replaced and held securely by small nails. While the old bark and the younger layers of wood remained permanently severed, the formation of additional tissue was greatly stimulated by this treatment. The new phloem and xylem were two to four times as thick as in adjacent regions where the cambium remained under normal pressure of the encircling bark. In a few cases the bark was not replaced after cutting the sapwood. The treatment was given to branches of trees used in the experiments described in previous paragraphs. Suitable checks were left in all cases.

TABLE III

Effect of Cutting the Sapwood on the Set of Apples

Lot and Variety	Sapwood cut bark replaced, sapwood cut and ringed (a)		No treatment, bark removed and replaced (b), or ringed (c)	
	Number Flower Spurs	Percentage with fruit	Number Flower Spurs	Percentage with fruit
1. Early Strawberry	350	5.4	364	34.9
2. Early Strawberry	344	17.7	(b)433	37.8
3. Early Strawberry	(a)324	0.0	302	33.2
4. Early Strawberry	(a)492	6.9	(c)440	43.0
5. Rhode Island Greening	250	0.0	212	33.5
6. Rhode Island Greening	(a)308	11.7	357	33.9
7. Thompkins King	242	6.1	(c)157	85.0
8. Baldwin	157	0.0	(b)163	30.8
9. Baldwin	195	0 0	211	22.8
10. Falawater	150	0.0	(b)132	41.7

The data in Table No. III show that the set has been reduced, or eliminated, by cutting of the sap wood wherever the treatment was given. It will be observed that the temporary removal of the bark has had an effect similar to though not as marked as that resulting from ringing. While ringing accompanied by very slight injury to the sap wood may easily show an increase over limbs that have had no treatment, it is probable that even such injury would tend to counteract the beneficial effects of removing only bark. In all the cases shown in the table the foliage remained on the treated limbs even though the fruits were shed. It is of course not always possible to judge the thickness of the functioning wood, and the cut may often go beyond the younger xylem into the brown winter injured tissue. This usually causes rapid drying and death of the leaves as well as the flowers within a few days. In some cases the leaves may wilt badly on clear days, and again resume turgidity during the night, or whenever the atmosphere is humid. If permanent wilting and death do not occur during the first week or so after cutting the

sapwood, the re-establishment of the conduction tissues which occurs very soon may prevent further danger. The new leaves on the secondary growth arising from the fruit cluster basis of the treated branches may be normal or larger in size.

While the lack of water during the critical period, when the flowers are open and for a few weeks thereafter, results in the shedding of practically all the flowers, the same treatment given when the young fruits are one-half to three-quarter of an inch in diameter, is less fatal. It has not been possible to cause abscission by cutting the sapwood after the apples were an inch in diameter: At such time the leaves and the fruits suffered equally, though both remained attached. Evidently the cells in the region of abscission soon become less responsive and finally irresponsive to rather drastic treatments. But fruits that have survived the earlier drops are by this time also more able to compete for water and growth producing substances.

Concluding Remarks

It has not been possible in these experiments, which involved trees of varying vigor, to reduce the set of flowers already formed by either ringing or by the application in spring of liberal amounts of sodium nitrate. On the other hand, both of these treatments seem to have a tendency to increase the set of fruits in flower-bearing trees of a given vigor. Cutting of the sapwood, however, seems always to reduce the set and may counteract the favorable influences of ringing or nitrate application. Such treatment undoubtedly increases the resistance to the movement of water and favors incipient wilting in succulent tissues of the flowers and young fruits.

It is not improbable that the beneficial influence resulting from ringing as well as those that follow the application of nitrogen, could be traced to their effect on the water attracting and moisture holding capacity, or the water requirements of the tissue. It can be shown that the accumulation of carbohydrates increases the osmotic pressure and strengthens the conducting tissues of the young fruits. The increase in nitrogen which favors succulency may facilitate the sap flow, and also cause a more economical use of water. It is known that apple trees well supplied with nitrogen may make more growth than control plants which have more soil moisture, but less nitrogen (Lyon et al 1923). The relationships among the percentage of flowers that set fruit, the vigor of the spurs, and the seed content of the apple, may also be accounted for to a large extent by the influences on water supply and utilization in the organ liable to abscission (Heinicke 1917).

While the emphasis is thus placed upon the importance of sustained turgidity during the critical early stages of the fruit development, it is of course not to be implied that such development could proceed without an adequate supply of growth producing substances. Nitrogen and carbohydrate apparently may be present in any proportions relative to each other that it is possible to bring about early in spring during the time abscission usually

occurs, in trees that produce a satisfactory number of perfectly formed flowers. The developing fruit at that time seems to be able to utilize, adapt itself or remain indifferent to, a large excess of either of these materials. In other words, the influence of extremes in the $\frac{C}{N}$ ratio in the chemical composition of the cluster base or adjoining tissues on the formation of abscission layer in normal flowers or young fruits, seems to be slight as compared with the influence of disturbed water relationships during the early stages in fruit development. The importance of suitable $\frac{C}{N}$ ratios for the initiation of fruit bud formation and for the development of a large number of functionable flowers is a problem distinct from the one now discussed.

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Oxidase Activity in Varieties of Apples

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We have all tasted high quality apple varieties that have lost flavor and acidity in cold storage. This is especially noticeable in highly aromatic varieties like McIntosh. I have tried many ways of preventing this deterioration without much success. Some qualitative tests of oxidase activity carried out in my systematic pomology classes, suggested an interesting field for investigation.

These tests soon gave promise of throwing some light on the above question.

Literature on Oxidase Enzymes

I have found little literature on enzyme activity in fruits. Thatcher claims that oxidase is the most important enzyme concerned in the ripening changes in apple tissue. Tunmann (8) describes the enzyme tests used in this work.

Methods Used

In the qualitative tests, I used violamine, (tetramethylparaphenylene diamine chloride), guiacum gum and benzidine. The latter is less expensive, easy to handle and easy to record by photographs. The first and second tests were used to check the accuracy of the benzidine tests. Violamine was used at various strengths, and made up by mixing with boiling distilled water. It should be used while fresh. This reagent gives a violet color in the region of oxidase activity. The violet color has a tendency to run. This obscures the localization. Guiacum gum was mixed with 70 per cent alcohol. This gives a blue color in the region of oxidase activity. Benzidine was mixed with 60 per cent alcohol; first mixing in 95 per cent alcohol and diluting to 60 per cent. A 3 per cent benzidine solution seemed to give the best reactions for photographing. Slices of apple one-fourth inch thick, (made by a slicing machine, through the center of the core), were left in 35cc. of the above solution at 70°F. for 30 minutes. The region of marked oxidase activity turned a dark blue, if the tissue was acid, or brown if alkaline. When a given variety had been tested a number of times and with several methods until confident of the results, a photographic record was made. Upon removing the slice of apple from the benzidine solution, it was wiped off with a dry piece of cheese cloth and photographed with a vertical camera using a color screen. This caused blue to record black. The station photographer made the exposures while I carried on the tests.

Quantitative determinations were made by the Bunzel method (1)using pyrogallol. Unfortunately my temperature control was not very constant. I have, therefore, used these determinations merely to check the accuracy of the benzidine tests.

Reactions Noted and Discussion

One set of benzidine tests was made in April, 1923, on fruit of the 1922 crop. This fruit, for the most part, was quite ripe. These reactions seemed a little stronger than in a second series of tests made in the fall soon after picking the fruit. Otherwise the results seemed identical. In addition to this, tests were made from time to time on the developing fruit. Localization of enzyme activity in McIntosh was noticeable as early as July. This became more noticeable as the fruit developed. I did not find any change in region of localization of oxidase activity during the development of the apple.

Apple varieties can be divided into three classes in respect to localization of oxidase activity.

CLASS 1. Torus reaction class. See fig. 1, plate I.
Oxidase activity localized near the skin and more or less irregularly in other parts of the apple. Maiden Blush, Ben Davis (northern), Gano (northern).

CLASS 2. Nearly uniform reaction class. See fig. 2, plate I.
Little or no localization of oxidase activity. Varieties of this class give a strong reaction. Red Astrachan, Early Harvest, Yellow Transparent, Williams.

CLASS 3. Core tissue and core line reaction class. See fig. 3, plate I.
Varieties of this class have little oxidase activity in the torus part of the apple. Canada Baldwin, Baldwin, Wagener, Rhode Island Greening, Roxbury, Winesap, Delicious, McIntosh, Grimes, Opalescent, Northwestern Greening, Banana, Fall Pippin, Wealthy, Rambo, Chenango, Lawver, Ontario, Pewaukee, Ben Davis (southern), Ralls (Geneton), Terry, Peck Pleasant, Oldenburg, King David, Northern Spy, Tompkins King, Esopus (Spitzenburg), Lady, Jonathan, Rome Beauty, Stark, Stayman Winesap, Yellow Bellflower, Arkansas Black, Gravenstein, Washington Royal, Courtland, Golden Delicious, Salome, Wolf River, Kinnard, Gano (southern), Deacon Jones, St. Lawrence, Nassau.

There are a dozen or more varieties that seemed to come in Class 1, if tested when freshly picked. My later tests have not confirmed this observation. This entire class needs further testing. You will perhaps notice that Ben Davis and Gano are listed in both class 1 and class 3. Shaw (6) found that northern grown specimens of Ben Davis were more conical than southern. Very long, conical specimens of Ben Davis from the College orchard at Amherst gave a test for class 1 when freshly picked (see fig. 1). Oblate specimens gave a test for class 3. Most specimens gave an intermediate test. This was further confirmed by testing specimens from many parts of United States.

Red Astrachan, when a little before hard ripe, gave a negative oxidase test. When "eating ripe" the test was as shown in fig. 2. This was repeated many times with the same results. I did not find this true for other varieties of apples. There are undoubtedly variations in the amount of oxidase activity in varieties of apples. This has been shown by the work of Thatcher (7) and my quantitative determinations confirmed this. These qualitative tests suggest that long keeping varieties have less oxidase activity than summer varieties like Red Astrachan and Yellow Transparent.

Class 3 could be divided into core tissue and core line testing varieties. I do not see any reason for so doing. In addition to the above, there are a number of sweet apples and varieties of low acid content, that I have not listed. My preliminary tests indicate that they would fall into the above classes, but I prefer to test them further.

Similar sets of tests for pears, quinces, and crab apples were less satisfactory (fig 4 and fig. 5). They seem to go into the same

classes as apples. Many pear varieties are a combination of class 1 and class 3, giving both a torus and core tissue reaction. Degree of ripeness, and treatment after picking seemed important factors in tests with pears.

Floa (3), Menten (5), and Bunzel (2) have discussed the accuracy of color tests in general. We are interested in "why" this localization of the reaction near the core. Would we not expect oxidase activity to be localized near the skin as we find in the potato by testing with benzidine? The strongest reactions are in, or about, the vascular bundles. All varieties, (so far as I know), in class 1 have considerable flesh between the base of the calyx tube and the core cavity. These facts suggest that it might be a question of oxygen supply. According to this theory, oxygen enters largely through the basin end of the apple. The gas exchange could then be aided by the vascular system, (Kraus (4)), which is present in the core flesh. This theory led to a series of tests using paraffin to seal the basin end of apples and pears.

I chose two lots, as uniform as possible, of McIntosh, Northern Spy, Delicious, and Baldwin. I sealed the basin end of one lot with warm melted paraffin. The treated and untreated fruits of a given variety were then placed in the same basket, but separated by a single sheet of paper. I wanted a high, a medium, and a low temperature, so I chose my kitchen, my cellar, and a cold storage room. The latter averaged about 35°F. All four varieties were tested at the high and low temperature. Only Delicious was tested at the medium temperature.

In general, the check or untreated fruit, gave off aroma characteristic of ripening apples much sooner and more rapidly than the fruit with basin end sealed. This was especially noticeable with McIntosh and Delicious. The treated McIntosh, (and other varieties), tasted superior to the untreated fruit within a short time after treatment (length of time varying with temperature). At the high temperature, a check lot of McIntosh lost much of their flavor within seven days. The treated McIntosh retained much of the flavor for over three weeks. Some specimens, at the kitchen temperature, even retained some flavor for over two months although the temperature averaged over 70°F. Fruit with basin sealed with paraffin soon tasted slightly sweeter. This increased somewhat with time, but did not become objectionable. This increase of sucrose suggested that we had retarded oxidase activity in the entire apple. The benzidine tests confirmed this. In about one month the benzidine tests with treated fruit became negative or nearly so. In about two months, the check McIntosh at the high temperature showed brown or dead areas in the core flesh. The treated specimens appeared normal. In addition to the above, treated fruit, at first, seemed to mellow faster than the check fruit. The increased sucrose seemed to mask the acidity somewhat.

The above suggests a possible explanation of my irregular tests in class 1. Oxygen might enter through fibro-vascular bundles that connect the calyx tube and core cavity. This might take place

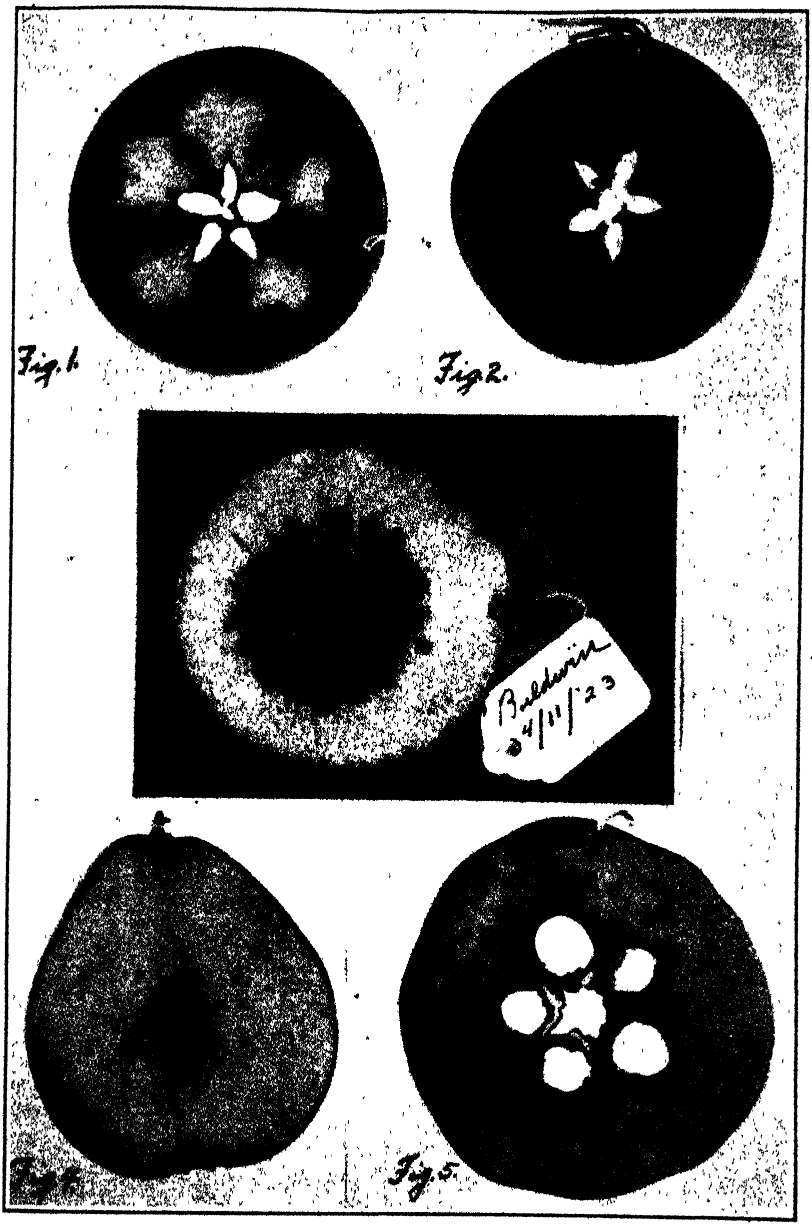

Fig. 1. Ben Davis Apple. The dark area indicates oxidase activity. This is typical of class 1 varieties.

Fig. 2. Red Astrachan. Oxidase is quite active throughout the entire apple. This reaction is typical of class 2, which includes many of the summer varieties of apples.

Fig. 3. Baldwin. Many varieties of apples have oxidase activity localized near the core as in the Baldwin. It may be said that the core acts like a ventilator with these varieties.

Fig. 4. Anjou pear showing oxidase reaction. The dark areas indicate oxidase activity. Typical of many oxidase activity reactions with pears. Varieties subject to core-rot usually show greater reaction in the core tissue.

Fig. 5. Orange variety of quince. The flesh is very dense and does not show the reaction well. Typical of many oxidase activity reactions with quince varieties.

more readily after the fruit had been picked for some time than before, or at the time of picking.

While the above tests were in progress, I sealed the basin end of some Le Conte, Anjou, and Bosc pears, leaving the usual checks. The untreated specimens of Le Conte, and to a less extent, Anjou and Bosc "core rotted." The treated fruit did not core rot until decay had gained access from the torus part of the pear. Some specimens of Le Conte showed some rot in the stem end, or cavity. This suggests that oxygen might gain access at that point also. In addition to the above, the treated pears seemed to ripen much like pears packed in wheat bran, or oats, and had developed high flavor.

Most of these tests have been carried on with a relatively small amount of fruit. There are many points that need further testing. Perhaps other materials than paraffin will be more convenient to use on fruit. It is possible that a mechanical device can be perfected to seal the basin ends of apples and pears on a commercial scale. Perhaps the oiled paper wrap acts as a partial seal to the basin end of apples. Some material might be found that could be sprayed rather than poured into the basin.

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Nitrogen and Carbohydrate Composition of the Developing Flowers and Young Fruits of the Apple

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Up to the present time very little of the analytical work in pomology has been done upon the developing flowers and young fruits alone, but rather wholly, or in part, upon organs and tissues more or less woody in nature. The author considered, therefore, that it might be of value to determine the chemical composition of the flower and very young fruits in order to find out the relative amounts of the various substances entering into these parts of the tree.

The work reported here is only a phase of the analytical work being carried on with material collected during the past three years from 13 year old trees of Roxbury Russet and Hubbardston, and from young and old trees of Baldwin. In addition to the nitrogen and carbohydrates, ash, phosphorous, and potassium, are being determined. However, for lack of space only a part of the data can be presented at this time.

Consequently, this paper will consider only the relative amounts of nitrogen and carbohydrates in the expanding flowers and young fruits of the apple at various stages in their development. Collections were made at certain times beginning with the opening of the fruit buds in early May up to the middle of June, at which time the young fruits had passed through the "first" drop and were approximately one-half inch in diameter.

It is well known that immediately after the petals fall certain flowers increase in size rapidly, while others in the same flower cluster may not enlarge appreciably, or at all, but hang for a few days and then abscise. Not only, therefore, was it the purpose of the investigation to determine the chemical composition of the flowers, but also the composition of the young fruits which will fall at the "first" drop subsequent to blooming, and also of those which will remain and develop further. It was also necessary to analyze the young fruits just as the last of the petals had fallen in order to have a stage in which it could reasonably be assumed that all the fruits were of practically the same chemical composition.

The flowers were taken from 13 year old Roxbury Russet trees growing in the University Orchard at Ithaca, New York, under the best orchard management. Although 25,000 flowers and young fruits were collected from five trees of this variety, for lack of space only the data from two trees (11,000 flowers and young fruits), are presented here. The other trees gave similar results in all cases. As far as possible two samples were taken from the same tree at each collection while with the trees not given here, four samples were taken from each collection, two of those fruits which were going to stick, and two of those which were going to

Analyses of Flowers and Young Fruits of the Apple—Roxbury Russet, 1923

Tree	Date	Stage	Number of flowers	Basis of single flower					Percentage of green weight					Percentage of dry weight			
				Green weight (milligrams)	Dry weight (milligrams)	Nitrogen (milligrams)	Free reducing substances (milligrams)	Total sugars (milligrams)	Dry matter	Nitrogen	Free reducing substances	Total sugars	Total polysaccharides	Nitrogen	Free reducing substances	Total sugars	Total polysaccharides
0 14	May 7	Flowers unopened	1390	60.0	12.0	0.64	0.22	0.50	19.98	1.070	0.37	0.84	2.42	5.35	1.85	4.20	12.13
0 14	May 21	Central flowers open															
		1st sample	373	307.0	41.9	1.74	3.38	4.60	13.64	0.565	1.10	1.50	1.98	4.14	8.09	10.96	14.49
		2d sample	409	292.0	41.2	1.76	3.66	5.27	14.07	0.602	1.25	1.80	2.26	4.28	8.89	12.81	16.07
0 15		Same															
		1st sample	599	261.0	41.0	1.70	3.80	4.85	15.72	0.650	1.46	1.86	....	4.14	9.26	11.81	....
		2d sample	...	.....	....	....	....	....	15.62	0.620	1.64	2.08	2.05	3.96	10.48	13.36	13.15
0 15	May 26	Full bloom															
		1st sample															
		(Petals only)	(339)	(145.0)	(17.9)	(0.34)	(4.83)	(5.10)	(12.31)	(0.233)	(3.33)	(3.51)	(0.91)	(1.89)	(26.99)	(28.47)	(7.38)
		(Receptacles only)..	339	180.0	35.7	1.52	2.33	3.74	19.83	0.844	1.30	2.08	2.29	4.25	6.55	10.48	11.54
		2d sample															
		Entire flower	344	318.0	52.9	1.87	7.32	8.94	16.65	0.587	2.30	2.81	2.07	3.52	13.81	16.88	12.41
0 14	June 1	Petals fallen															
		1st sample	789	169.0	38.5	1.60	2.85	3.52	22.65	0.943	1.68	2.08	2.52	4.16	7.43	9.17	11.12
		2d sample	...	.....	....	....	....	....	22.49	0.872	1.56	2.00	2.59	3.89	6.91	8.88	11.52
0 15		Same															
		1st sample	...	.....	....	....	....	....	21.25	0.900	1.38	1.81	2.48	4.23	6.49	8.53	11.67
		2d sample	760	191.0	40.3	1.76	2.46	3.21	22.61	0.923	1.29	1.68	2.37	4.36	6.11	7.94	11.23
0 14	June 7	Fruits sticking	144	478.0	77.0	3.14	3.01	....	16.00	0.658	0.63	....	2.15	4.11	3.93	....	13.43
		Fruits abscissing															
		1st sample	811	155.0	33.1	1.04	2.12	2.37	21.35	0.649	1.37	1.53	2.34	3.15	6.40	7.18	10.96
		2d sample	558	161.0	35.5	1.11	2.15	2.63	22.02	0.690	1.34	1.63	3.16	3.13	6.06	7.41	14.36(?)
0 15		Fruits sticking	203	628.0	99.3	3.97	3.57	4.73	15.80	0.632	0.57	0.75	2.07	4.00	3.60	4.77	13.13
		Fruits abscissing															
		1st sample	707	139.0	28.9	0.82	1.55	1.98	20.81	0.592	1.12	1.43	2.39	2.84	5.37	6.86	11.50
		2d sample	808	132.0	33.4	1.00	1.68	2.10	21.23	0.634	1.07	1.33	2.23	2.98	5.02	6.28	10.48

abscise. All samples were taken indiscriminately around the tree in order to lessen the errors of sampling. The material was collected in weighed closed pint jars, taken to the laboratory, weighed and heated in alcohol at 75-78°C. for an hour. The methods of preservation and extraction of samples were in general those used by Kraus and Kraybill in their work with the tomato. As far as possible samples of at least 100 grams green weight were collected, each sample made up of 200 to 1600 flowers, or young fruits, depending upon the stage. The trees had a fine crop of fruit buds and blossomed abundantly in all cases. The collections did not remove all the flowers since many abscised naturally at the "first" drop, while others went on to maturity giving a fair crop of fruit at harvesting time.

The collections were taken on May 7 and 21, June 1 and June 7, 1923.

On May 7, the fruit buds had opened enough to allow the removal of the individual flowers of a cluster without the inclusion of any leafy tissue associated with the flowers in the bud. The central flowers were only occasionally pink-tipped, while, as yet, the laterals showed no trace of color. Care was taken to remove all the flowers of an individual cluster.

On May 21, the central flower of the cluster was nearly wide open, while the lateral flowers did not as yet have petals of full size, or separated enough to expose the stamens. The trees were just in full bloom on May 26 when a collection was made for the separate analysis of the petals and the remainder of the flower after the removal of the petals.

On June 1, the flowers were collected just as the last of the petals had fallen. Care had to be taken not to include any half dried petal tissue which had not as yet fallen to the ground. In those clusters in which the central flowers were appreciably advanced over the lateral flowers, only the latter were taken. In other words, this stage represents one in which the flowers, or young fruits, as one may wish now to call them, were all alike as far as could be observed from their outward appearance. Occasionally the central flower seemed to snap off rather easily and consequently was not included in the sample. All the lateral flowers were removed with the same degree of difficulty which indicated that as yet no abscission layer could have been formed.

On June 7, six days after the third collection, a very noticeable difference in size had taken place between the young fruits. Certain ones were much larger than others and could be removed from the cluster base only with difficulty. These were approximately one-half inch in diameter. Those which had not increased appreciably, or at all in size over the third stage, could easily be snapped off. Although their pedicels were slightly yellow in many cases, these young fruits were not in the least wilted or dry, and would have hung several days without abscissing. There was, therefore, not the least doubt at this stage as to those young fruits which were going on further toward maturity, and those which were about to abscise.

Method of Analysis

Nitrogen was determined by the Gunning method modified to include nitrates.

Carbohydrates

The free reducing substances were determined gravimatrically by the Munson and Walker General Method. The official method of direct acid hydrolysis was used for the conversion of the polysaccharides to reducing substances. In order to clarify the solution it was found necessary to use tannic acid followed by lead acetate rather than by lead acetate alone.

Expression of Results

In all cases the values given in the table for nitrogen and the free reducing substances are the averages of two determinations which vary only slightly from the mean. The carbohydrates are expressed in terms of dextrose.

Discussion of Data

The data in the table show that the percentage of dry matter was lower in the second collection, May 21, than in the first collection, due no doubt, to the enlargement and growth of the petals which may represent 35-50 per cent of the green weight of the flowers at full bloom. The petals alone had a moisture content of 87.69 per cent, the receptacle alone 80.17 per cent, while the analysis of the second sample made up of the entire flower, showed a value of 83.35 per cent. The dry matter of the flowers on the percentage basis naturally increased with the fall of the petals (third stage) reaching approximately a value which we might expect considering the loss through the petals and pollen. In the fourth collection those young fruits which were going to abscise showed practically the same percentage dry matter as they had at the previous stage, June 1, while those which were sticking had much more moisture.

Attention is called to the values for the green and dry weights of the individual flowers. At the fourth collection the young fruits which were going to abscise seemed to have lost in dry matter slightly compared to the amount present at the previous stage, while those young fruits which were going to stick have more than doubled in dry weight.

It is here also that we get an idea of the relative size of those young fruits which were going on further toward maturity and those which were to abscise shortly. The young fruits which were going to stick had three to four times the green weight of those which were going to fall.

Nitrogen

The nitrogen content has been expressed in this paper not only in percentage of green and dry weight, but also in milligrams per individual flower. Sufficient numbers of flowers and young fruits were collected to prevent any small errors in the nitrogen determination having a significant effect upon the nitrogen content of the individual flower.

On the dry weight basis the data showed a high content at the

first stage when the fruit bud had just opened, followed by a small decrease at blooming time to a value slightly over 4 per cent, which remained constant until after the petals had fallen. In the fourth collection there was practically no change in nitrogen in the young fruits which were going to stick, while there was a decided decrease in those which were going to fall to approximately 3 per cent. The latter had distinctly less nitrogen than the young fruits which had increased in size and were going on further toward maturity.

It has already been mentioned that on May 26 when the flowers were just in full bloom two samples were collected, in one of which the entire flower was analyzed, while in the other the petals were removed and analyzed separately. This was done not only to get an idea of the relative amounts of nitrogen and carbohydrates in the petals, but also to obtain values for the receptacle which is, of course, that part of the flower which falls at the "first" drop, or else developes further. It is, however, with the nitrogen on the basis of the individual flower that the more striking results were obtained. The nitrogen tripled from the earliest stage to full bloom and the third stage showed approximately the amount we should expect considering the loss through the fall of the petals and pollen. Attention is called to the appreciable though small amount of nitrogen in the petals which reached nearly one-sixth the total amount in the flower at full bloom.

Futhermore, the fourth collection shows two very decided trends to the nitrogen content of the individual flower. In the first place the young fruits which were sticking had nearly three times more nitrogen per fruit than those which were going to fall. But what is more striking is the actual decrease in nitrogen of those young fruits which were about to abscise compared to their nitrogen content at the previous stage taken six days before. The decrease amounted to 30-43 per cent less nitrogen in all cases, while those which were going to stick more than doubled their nitrogen content in the same length of time.

Free Reducing Substances

The free reducing substances increased very markedly from May 7 to May 26, due principally to the large amount present in the petals at full bloom. The third stage naturally showed a decrease in percentage while a comparison of those fruits which were going to stick and those which were about to abscise shows a much smaller amount in the former than in the latter, which were going to abscise. On the basis of green weight there was less than half as much reducing substances in those which were vigorously growing.

The sugar content of the individual flower jumped 30 times from the first collection to the second reaching at full bloom a value of 13 per cent of the dry weight and over two per cent of the green weight. The data indicates that over 60 per cent of the free reducing substances at full bloom may be in the petals and consequently be lost to the tree with petal fall.

The third stage just as the petals have fallen, showed approximately the amount of sugar that might be expected considering

the loss with the petals. In the fourth collection we observe a ratio not greater than 1 to 2.2 between the free reducing substances of those which were about to abscise to fall and those which were going to develop further. However, the ratio of the green weight of the two was in no case less than 1 to 3 and ran as high as 1 to 4. Naturally, therefore, we would expect more free reducing substances in the individual fruit which is larger and the amount would vary as the difference in size between those which will stick and those which will fall becomes greater. An examination of the data also shows less free reducing substances in those which were about to abscise than they had at the previous stage taken just as the petals had fallen.

Total Sugars

The total sugars in general follow the same trend as the free reducing substances which make up by far the greater part of the total sugars in the flowers and young fruits. The fact that the young fruits which will abscise have distinctly less total sugars than they had at the previous stage indicates that the decrease in free reducing substances in these young fruits is not due to a conversion into any of the disaccharides.

Total Polysaccharides

The acid hydrolyzable polysaccharides were determined and while the values given may show the trend, the author wishes as yet to draw no conclusions from them. The extreme difficulty of properly clarifying the extract has been a complicating factor in the determination of this form of carbohydrate.

Summary

This paper has presented data obtained by chemical analysis of the nitrogen and carbohydrate composition of the flowers and very young fruits of the apple.

The dry matter of the developing flowers and young fruits has been given not only on the percentage of green weight basis, but also on the basis of a single flower. The greater water content of the young fruits which will survive the "first" drop compared to those which will abscise, is particularly noticeable.

The nitrogen content upon the dry weight basis was rather high when the flowers separated out of the bud, but gradually decreased to a level of approximately four per cent in those young fruits which were going to stick, while upon the single flower basis, the nitrogen had naturally increased markedly. Those young fruits which were about to abscise lost nitrogen from the time the petals fell until they abscised.

The free reducing substances increased to high values with the enlargement and growth of the petals, but falls to a comparatively low level in those fruits which survived the "first" drop and were growing very vigorously. Upon the dry weight basis there was a distinctly greater amount in those which were going to abscise although the individual fruit which was going to stick had a greater amount because of its larger size. The data show that the free reducing substances made up the larger part of the total sugars.

The decrease in free reducing substances in those fruits which were going to stick was not accompanied by an increase in the total sugars.

It has already been pointed out that this work is being continued with similar material from two other varieties. The author, in conclusion, wishes to express his appreciation to Dr. A. J. Heinicke for his valuable advice in the carrying out of this investigation.

An Explanation of Certain Growth Responses of Apple Shoots to Ringing and Defoliation

By E. M. HARVEY, *Oregon Experiment Station, Corvallis, Ore.*

THIS address is only a preliminary abstract of a report on investigational work which will be printed in bulletin No. 200 of the Oregon Agricultural Experiment Station.

Secondary Flowering of the Apple

By C. G. VINSON, *Experiment Station, Wooster, Ohio.*

SECONDARY flowering in the growing season of 1923 took place abundantly on Wilson Red June in the orchards of the Ohio Agricultural Experiment Station. This secondary flowering was found on young trees seven years old and on old trees also. The secondary clusters opened over a considerable period of time. Some of the secondary flowers were open by the time the petals began falling from primary clusters, while others did not open until much later. Most of the secondary clusters on the younger trees were borne on the terminals of the secondary shoots from primary cluster bases as described in the 1922 report of this Society. Two hundred and fourteen such fruiting shoots, averaging about six centimeters in length, were found on the younger trees. There were many gradations in character of growth of the upper secondary axis from the primary cluster base. These gradations represented intermediate stages between the lowest flower of a primary cluster, which is usually axillary to a large leaf, through to a secondary axis consisting of merely an elongated pedicel with a *single terminal flower;* also to a stockier shoot-like secondary axis with one or more bracts upon it and a *terminal cluster* of three to four flowers which opened; and to a still more shoot-like growth with terminal *flower buds which did not open;* and to a purely *vegetative, secondary axis.* Where the secondary axis bore a terminal fruit cluster, the vegetative secondary, without exception, arose in the axil of the next lower leaf. At times both secondaries were purely vegetative and in such case their relative positions were the same as when one flowered. The flowering secondary, without exception, was always the upper one, and was always the first one to

push. In other words, where there were two laterals from the primary cluster base, one reproductive and the other vegetative, or both vegetative, the upper was always ahead of the lower. No case was found in 1923 in which both laterals flowered.

The pedicels of flowers on the terminals of secondary shoots were usually quite short. In many of these secondary clusters fasciation had taken place between the individual receptacles and often two or more were united. The shorter the flower pedicels the more likely this seemed to occur. Some of the secondary flowers set fruit but none was carried to maturity. Some, however, did carry until about one centimeter in diameter. Such small fruits had no well developed seeds, for only papery seed coats, which were empty, were found on cutting these open.

At the same time the ordinary secondary clusters were opening, other types of unusual shoot growth were found developing from terminal buds. On Thursday, May 24, Professor Gourley found a shoot, from a terminal bud, with laterals developing simultaneousy with the central axis of the shoot. Upon examining this shoot it was seen that some of the laterals and the central portion had terminal flower parts of some sort, although the flower parts could not be seen. Twenty-nine other shoots similar to this one were found. Some of these, when found, were more advanced than others and from these the course of development of all was quite plain. Some of these shoots had as many as six laterals and some had only three. Some had terminal flower buds on the laterals and central portion, while in other cases the laterals and central portion were entirely vegetative. There were various gradations between these two extremes and finally it was decided that these unusual types of shoots indicated the course of the progessive development of the ordinary flower clusters, as we know them at present.

Where the laterals and central portion were vegetative, elongation continued for some time as can be seen in the case of shoot No. 12, which had five vegetative laterals and a central portion:

Lateral No. 1 was 2.5 cm. long and had 2 leaves when length growth ceased.
Lateral No. 2 was 11.7 cm. long and had 5 leaves when length growth ceased.
Lateral No. 3 was 13.5 cm. long and had 7 leaves when length growth ceased.
Lateral No. 4 was 12.8 cm. long and had 7 leaves when length growth seased.
Lateral No. 5 was 10.0 cm. long and had 6 leaves when length growth ceased.

From the base of the last lateral to terminus of central portion the length was 14.5 cm. and this portion had eight leaves.

In the case of No. 36, where the laterals and central portion bore terminal flower buds, length growth ceased early and the parts were of the following length:

Lateral No. 1 was 2.0 cm. long and had 2 leaves when length growth ceased.
Lateral No. 2 was 1.3 cm. long and had 2 leaves when length growth ceased.
Lateral No. 3 was 1.8 cm. long and had 2 leaves when length growth ceased.
Central portion was 3.5 cm. long and had 2 leaves when length growth ceased.

The terminal flower buds on some of the laterals and central portions opened while with others the terminal flower buds abscised before opening. In every case where a lateral or central portion had a terminal flower bud which opened, that lateral or central

portion abscised; while in every case where the terminal flower bud abscised before opening the portion bearing the bud never abscised but remained on the shoot.

One condition which was prevalent with most of the branched shoots was that the laterals often seemed to arise some distance above the axil of a leaf, leaflet or bract. But in every such case the lateral was decurrent, a more or less visible rib extending from the base of the lateral to the axil of a leaf, leaflet or bract, immediately below, where the rib ended abruptly. It would seem quite apparent in such cases that the lateral had been laid down in the axil of the leaf, leaflet or bract, and had become united for some distance with the central portion. This, undoubtedly, was the manner in which the unusual flowering shoot arose which was found on Oldenburg in 1922, and dwelt upon in the last report of this Society. So many cases were found in 1923 that the origin of such shoots became clear.

The manner in which proliferated fruits develop became somewhat clearer in 1923. Most of the flowers which opened on the branched type of shoot had enlarged sepals, enlarged supernumerary sepals, or enlarged leaves at the base of the receptacle. There was no sharp dividing line between the large supernumerary sepals and the large leaves, although in the former there was no distinct petiole. Sometimes one or more of the five sepals would be greatly enlarged. In other cases the enlarged sepals would be supernumerary, that is would constitute part of another whorl. At other times the large laminal portion would have a distinct petiole, though short, and would then be like an ordinary leaf. These laminae with petioles were never in the same whorl with the sepals of ordinary size, but were usually inserted at the base of the receptacle. The latter type of flower would undoubtedly have produced a proliferated fruit had it set.

Several days after the unusual branched shoots were discovered a telescoping effect was noticed at the terminals of long unbranched shoots. These shoots were watched very closely and it soon became apparent that they had terminal flower buds. Ten such shoots were found on young trees of Wilson Red June. Flowers opened from a few such terminal flower buds, but most of these buds abscised before the flower parts showed pigmentation. Those flowers which did open, in contrast with those on the branched shoots, were of the ordinary type with normal pedicels, sepals of the usual type, and no leaves associated with the flower anywhere. The flowers on the branched and unbranched shoots, therefore, appeared very different. None of the flowers at the terminals of unbranched shoots set fruit with the exception of shoot No. 22. A cluster of three flowers, only two of which opened, was borne on the terminus of this shoot, at which time the shoot was 20 centimeters long and had 14 leaves. The two flowers were open June 13. There was a reduction of parts in some of the whorls as can be seen from the floral formulas, 1—K_5 C_4 A_9 G_5. 2—K_4 C_4 A_8 G_5. Pollen which was collected in May, was applied to the stigmas of the two flowers. Small, oblong, ridged fruits developed very rapidly, the temperature being high, until one was .4 cm. in diameter and the other

.6 cm. The smallest fell July 6 and the largest July 17. Upon cutting open these fruits no seeds were found.

On June 22, fully one month after petals had fallen from primary clusters, a terminal flower bud was found on an unbranched shoot which was 22.5 cm. long and had 14 leaves. This cluster abscised before the flower parts separated, and a very large bud in the axil of the next leaf below the terminal broke and from this axillary bud a cluster of four flowers emerged, only three of which opened. These flowers were borne on a very short cluster base. The first flower of this cluster to open was in full bloom June 29. None of these set fruit and the last one fell July 13. These flowers were like an ordinary flower in every respect, excepting that in the case of one flower one of the sepals was distinctly petaloid. Below this axillary flower cluster were very large buds in the axils of the next two leaves. These buds were as large as axillary buds in the dormant season. The other axillary buds on this shoot were scarcely visible at this time. In fact 1000 shoots, of the *ordinary* type, were examined on Wilson Red June at this time and none were found with such large axillary buds.

On a large Summer Pearmain tree, June 8, a cluster base was found, the primary cluster of which had aborted and from this cluster base two lateral shoots had developed. The upper shoot showed a telescoping effect, or a shortening of the internodes toward the terminus and a reduction in the size of leaves. Toward the base of this lateral, however, the leaves were large and were inserted along the lateral at ordinary intervals. No flower parts were visible June 8, but on June 26, apparently from the axil of the uppermost leaflet, a cluster of four flowers was emerging. This inflorescence was distinctly branched in appearance, as the lateral flowers were spaced at intervals of .5 cm. along the central axis. When the flower cluster was fully expanded the fruiting lateral was 24.5 cm. long and had 20 leaves and leaflets. None of the flowers set fruit and the last one fell July 23.

Discussion

In-so-far as securing proof of fruit bud formation in the spring previous to flowering the same spring, or early summer, was concerned, the results in 1923 were negative. On May 4, 500 blossom clusters in the pre-pink stage were removed from Utter. Thirty-six of these cluster bases had secondary clusters which were visible at this time. These secondary clusters were just one week behind the primaries in opening . Only two cluster bases, out of the 500, developed flower parts on secondary shoots, which were not visible at the time the primary clusters were removed. Hence one could not say, from the above, that removal of the primaries stimulated the production of secondary flower clusters.

The first impression upon seeing flowers opening on the terminal of long shoots, over a month after primary petal fall, was that the primordia of such flowers must have been laid down after growth began in the spring. But since the embryo shoots are laid down in the bud, and no period of rest or second growth had taken place before the flower parts appeared, it would seem entirely pos-

sible that the flower parts, too, could have been laid down in the growing season of 1922, though perhaps late in the season. In the case of shoot No. 38, which had a flower cluster develop from an axillary bud, it was very apparent that such large buds were formed before the shoot was fully expanded, for they were present as soon as the leaf had attained its full size. Eight other shoots were found with such large axillary buds early in the season, but on forcing some of these by wounding the twig at a point immediately above the bud, none, so forced, were found that contained flower parts. Laterals on the branched shoots were undoubtedly laid down the previous growing season, so the question might be asked why could not the large axillary buds likewise have been laid down the previous growing season also? With the long secondary shoots on Summer Pearmain the same may be true, but here the flowering lateral seemed to start strong, vegetative development, then very gradually, over a period of at least four weeks change in character of growth until the growth was reproductive instead of purely vegetative.

In 1923, practically all the flower clusters on Yellow Transparent at the Ohio Agricultural Experiment Station, were produced on shoots from cluster bases which fruited in 1922. On one large Yellow Transparent tree 259 flowers clusters, 1923 being their "off year," were found at the base of cluster bases of 1922. Only two other flower clusters were found on this tree and these were from buds which were immediately below a wound or break on a twig which suggests that the laying down of the above flower clusters, in some way, was connected with the wounding of the cluster base in 1922 due to premature picking of the fruit, which caused short laterals to push at the base of the cluster bases, in August, 1922. No such breaking of buds was noticed in 1923, however. Several clusters of fruit were removed fully three weeks previous to picking time but no pushing of laterals at the base of the cluster base resulted.

Summary

Attempts to induce secondary flowering, in case of apple, by removing clusters in the pre-pink stage, were unsuccessful in 1923.

Long shoots on Wilson Red June and Summer Pearmain were found with terminal flower clusters which opened the latter part of June and the first part of July. In the case of Summer Pearmain, it is believed the flower parts were laid down after growth started in the spring of 1923.

Large axillary buds were found on same shoots about the middle of June. One of these produced a flower cluster the latter part of June. This particular bud was located immediately below a terminal flower cluster which aborted. None of the other axillaries, when forced, produced flower parts.

Selecting Buds for the Development of Frame Work Branches of Apple Trees

By F. N. FAGAN, *Pennsylvania State College, State College, Penna.*

THE need of more careful work in selecting frame work branches of fruit trees made itself very pronounced to the workers at our Station some seven years ago, when the experimental apple orchard first began to produce an average yield per tree.

A word of explanation here is necessary. The workers who planned and planted our experimental orchard, took great care in securing varieties, true to name in the various fertilizer and culture method blocks. To be sure of the varieties, nursery trees were planted and top-worked at once to Stayman Winesap, York Imperial and Baldwin.

The common top-working methods were used with good results as far as "set" of scions is concerned. As we all know the common length of scion would have been about six to 10 inches. We also know that the distance between buds on these scions would have been about one to one and a half inches apart. We also know that the average grower would hesitate to do much pruning on these scions during the first two or three years of growth. This we feel is a true statement of facts and not at all removed from common practices.

This orchard came under the management of the present workers at the Station about six years ago, which was at the time the trees began to produce the first real crops of fruit. We realized what we were up against, as the frame work branches were bunched and not only poor crotches were present, but branches were beginning to wedge each other. Corrective pruning at that stage would have to be very severe, so bolting and wire trussing have been done to save the trees from breaking. At the same time as much corrective pruning as possible was done each year. Bracing is expensive work and is not absolutely permanent. If a fruit grower had to do more or less of this work on a thousand trees he would naturally be impressed with the need of correct tree training to avoid this expense and the loss of many trees.

The reader can readily see why we were impressed with the need of more careful selecting of frame work branches. We had just planted another orchard of 3,000 trees, using one year whips, and had made up our mind not to let such poor heads develop in the new orchard as had developed in the experimental orchard. The usual method of training was followed when these trees were prunned. At planting time the whips were cut back to 30 inches. Each year they have received a light thinning out of branches. Frame work branches have been selected as they developed. We thought we were getting some well shaped trees and believe we have succeeded about as well as the average grower following this

method. We do not, however, feel that we have the perfect trees we would like to see. With the experience of the two orchards at the Station and the experience our workers have had elsewhere, and still not being satisfied with the results obtained, we decided in the spring of 1923 to start a new project with a view of beginning with the bud on the one-year whip as our base for better frame work branches.

Fifty McIntosh and 50 Stayman Winesap one year whips, were secured and planted, and the project written into the Station records.

The idea was to remove all buds on the one year whips except the buds that occurred at intervals where in future years frame work branches would be desired.

Beginning with the bud as a starting point for training is not a new idea in pomology at all, for such is the method used by gardeners in Europe in much of their tree training work as is shown in the European literature, not only at the present time, but in the literature of the early part of the nineteenth century. Especially is this view point in evidence in espalier system of training. However, little is to be found in American literature along this subject.

We did not feel sure of our ground, or do we after our first year's experience. We realize that in removing all buds on a whip except the three to five desired for development into branches, we would reduce the total leaf surface on each tree during the first year's growth, and likely in the next two or three seasons also. This reduction might seriously reduce the rate of development of the entire tree.

The de-budding of the whips took place a few days after planting, and before any growth took place. The trees were not cut back and the terminal bud was permitted to remain. In removing the buds a dull knife was used, and the buds were not cut off, but merely flipped off by placing the cutting edge of the blade into the angle the buds formed with the trunk, and then with a slight turn outward with the blade, the buds were readily removed. The work was not tedious, and the rapidity with which it can be done does not place this detailed operation in the class of impossibilities.

In the next place we were confronted with the question, "would the three to five buds selected on the whip be sure to grow?" Time only could answer this question.

We are pleased to see that nearly every bud selected has developed into a branch. The exceptions are rare.

We were also confronted with the question of whether secondary buds would develop and grow at the nodes where the buds had been removed. In a few cases this has occurred, or the heart of some few buds may not have been completely removed. From these, a few branches have developed where frame branches were not desired.

We believe we see a mistake in our methods. No heading back was done on the whips, but we now feel that with the taller whips 6 to 7 feet long they might well have been headed just above the top bud selected. In our future work under this project, we will

likely head the taller whips just above the highest or top bud selected.

In conclusion let me state that we are quite well pleased with the growth that the de-budded trees have made. The contrast is plainly seen when comparing them with the few trees left in the planting not de-budded. No trunk growth has been taken at this date. No twig length growth has been taken. The trees themselves we are allowing to answer the various questions. The angle of the branch and its strength of tie to the main trunk, can only be answered after more years' growth. Our project is so written that data of growth in all details can be recorded. The first year's results encourage us, and it is expected the project will be continued.

Viburnum Americanum as a Garden Fruit

By G. M. Darrow, *United States Department of Agriculture, Washington, D. C.*

Introduction

In the spring of 1921, the Bureau of Plant Industry took over a plantation of *Viburnum americanum,* established by Mr. A. E. Morgan, at East Lee, Massachusetts, together with his interest in many experimental plantings of this fruit established at experiment stations in Northern United States. This paper constitutes the first report on this work.

Inception of the Work by Mr. Morgan

Mr. Morgan, in the course of his engineering work, had spent some time in Manitoba and Saskatchewan previous to 1914, and had there noted that the fruit of this plant was highly prized for its value in jelly making, being commonly gathered and sold in local markets. This aroused his interest and about 1914 a trip was taken through Northern New York and Northern New England to study the wild types, locate desirable bushes, and select sections in which to make a careful search for the best wild forms. In addition, specimens of fruit were secured through correspondence from Alaska to Newfoundland in 1914, to get as much information as possible regarding its character.

The section of New Hampshire about Lancaster just north of the White Mountains, was chosen as the most promising from which to secure selections, for many farmers in that vicinity have transplanted bushes to their yards and gardens in order to have a homegrown supply of fruit available. In the fall of 1915 Mr. Ray Hahs, and in the fall of 1917, Mr. Frank Andrews, were employed to make a careful survey of the region. They secured several hundred bushes for Mr. Morgan, and planted them at Jacob's Pillow near East Lee, Massachusetts. Seed also was planted in 1914, 1915, and 1917. Hardwood cuttings were made in the spring of 1916 and in the fall of 1917. In 1919 and in 1920 Mr. Morgan distributed

seedlings, plants propagated from cuttings, and a few divisions of the original bushes, to many experiment stations and institutions in northern states, establishing cooperative tests. These stations include that at Orono, Maine; Durham, New Hampshire; Amherst, Massachusetts; Geneva, New York; Madison, Wisconsin; Morris, Minnesota; Fargo, North Dakota; Bozeman, Montana; and Moscow, Idaho. A total of about 3300 plants were distributed.

After Mr. Morgan became president of Antioch College, Ohio, he offered to turn over his interest to the Bureau of Plant Industry, which was done in 1921. The principal plantation, through Mr. Morgan's generosity, is still located on his place near East Lee, Massachusetts.

Botany

Viburnum americanum belongs to the family *Caprifoliaceae* which includes also the common elderberry *(Sambucus canadensus)*, the honeysuckles (Lonicera spp.), diervilla, abelia, and other ornamentals. The bush is widely grown as an ornamental, its form adapting it to landscape uses, the foliage a rich green color in summer and highly colored in fall, and the berries contrasting well with the foliage and hanging into or through the winter. The fruit is used to a greater or less extent in sections to which it is native, for jelly making, marmalade, and for a fresh fruit drink. The bark yields a valuable and high priced drug.

Rehder states that there are, in all, about 120 species of Viburnum. Nearly all are natives of the Northern Hemisphere, mostly of the cooler sections, and the genus is circumpolar. They are mostly large shrubs with showy flowers and good foliage, some having decorative fruit also, and are widely used as ornamentals. *Viburnum americanum* is the only species of which the fruit is used to any extent. Fruit of *Viburnum pauciflorum* is reported as resembling that of *Viburnum americanum* and as being used in Alaska. Many species bear sweet, dark fleshed fruit, but the proportion of pulp to seed is usually very small. In South Carolina recently, however, a selection has been made of a large fruited sort with thick pulp. In northern India two species *(Viburnum cotinifolium* and *Viburnum foetens)* are reported as edible, but are probably of no more value than our common dark fruited ones represented by *Viburnum cassinoides*.

Distribution

Rehder gives the distribution of *Viburnum americanum* as Newfoundland and British Columbia, south to New Jersey and Oregon. It is common in some places in Northern New England, Northern New York, Northern Michigan, Northern Wisconsin, and Northern Minnesota, especially along streams and on hummocks in swamps. Mr. Morgan suggests that its location in such places may be due to the fact that the seeds do not germinate until the second or third year, and that the seedlings are tender and must receive ample moisture during the first season of growth. Bushes have often been transplanted to dooryards and gardens in the sections referred to and the fruit is occasionally found in the markets.

Viburnum americanum is commonly confused with *Viburnum*

opulis of Europe, but is distinguished from it chiefly by the intensely bitter inedible fruit of the latter, by the absence of, or only slight tomentum on the under side of the American species, and by the greater susceptibility of the European species to aphis injury. *Viburnum opulis* is as yet more common than *Viburnum americanum* in the nursery trade.

The main planting at East Lee, in the spring of 1921, the year when the Bureau of Plant Industry took charge, consisted of a field of about two acres set six by eight feet. In addition to the plantation set in orchard form, there was a considerable quantity of nursery stock as follows: (a) seedlings one and two years old, raised from seed from selected bushes; (b) older seedlings raised from seed collected in the fall of 1915; (c) hardwood propagations of the spring of 1916 from the selections planted in the autumn of 1915; and, (d) hardwood propagations of the selections made in the autumn of 1917.

The small seedlings were taken to the Bell Horticultural Station in Maryland and grown one year before distribution. The larger seedlings and the plants propagated from cuttings were sent out in the spring of 1921. Distributions were made to the experiment stations at Orono, Maine; Durham, New Hampshire; Amherst, Massachusetts; Geneva, New York; State College, Pennsylvania; Madison, Wisconsin; to the State Forest Nursery, Lake Clear Junction, New York and the office of Drug Plant Investigations, Washington, D. C. In 1923 plants were sent to the State Forestry Commission, Concord, New Hampshire.

At two places, the New York station at Geneva, and the North Dakota station at Fargo, some fruit was borne this year (1923), but hardly enough to determine the merits of the various bushes. One set of seedlings (No.10), at Fargo, North Dakota showed distinct winter injury. No other bushes, either seedlings or plants grown from hardwood cuttings, showed any signs of winter injury, nor has any lack of hardiness been observed elsewhere.

Selections Made by Mr. Morgan

The large number of plants secured by Mr. Morgan in 1915 were selections from the wild. Mr. Morgan had first made a careful survey of the bushes in Northern New Hampshire and adjacent parts of Vermont and Maine. Mr. Hahs then secured and shipped a carload of those considered of greatest value to East Lee, Massachusetts. In the autumn of 1917, Mr. Andrews was employed to make a much more careful survey of a part of this region. He selected and shipped to East Lee about 46 different sorts. His selections were based largely on size and color of berry, number of berries to the cluster, and productiveness of the bushes. The large bushes of both series of selections were divided, sometimes into many plants, at the time of setting. Many cuttings were taken for hardwood propagation and seeds were planted.

In 1919 and 1920, Mr. Morgan sent plants of some of the selections made in 1917 which he considered the best, to cooperating experiment stations for the purpose of testing their value in different sections. A few of these bore fruit in 1923, but the bushes

were not large enough to determine the relative value of the varieties. Those sent out are "Cole Number 9," "Fiske Number 12," "Hamlin Number 2,'" "Hazelton," "Howe Number 4,'" "Le Clair," "Monahan Number 34," "Smith Number 25," "Stevens," "Sutton Number 35," "Sutton Number 37" and "Weeks Number 41". The numbers refer to the selection number of 1917 and the name, for the most part, to the owner of the farm from which they were secured. They are here used merely as tentative designations and not as accredited variety names.

Selections Made in 1922

Mr. Morgan's selections were based upon the behavior of the bushes in the wild and his final selection was to have been based on the behavior of such plants after being placed under cultivation. The first crop from the plantation at East Lee was secured in 1922. About 10 per cent of the bushes, mostly the larger bushes, bore fruit. About 20 bushels were harvested. Unfortunately, very few of the selections of 1917 had a crop. Certain bushes however, were much superior to the rest and three varieties were selected for propagation for the value of their fruit. There are but few bushes of these in the plantation and several years will necessarily elapse before a sufficient stock for introduction can be propagated. Additional records during succeeding years will determine whether these selections are the best and should be introduced, or are inferior to others and should be discarded. Several bushes, striking as ornamentals, were also selected for propagation and introduction.

The three sorts selected for their fruit are "Wentworth Number 15" (of 1917), "Hahs," and "Andrews" (Number 18 of 1917). (Names are tentative designations only.) The "Wentworth" was selected by Mr. Andrews on the farm of O. E. Wentworth near Lancaster, New Hampshire, where it grew 12 feet high. Four bushes were made by division, one of which fruited heavily in 1922. It is a vigorous, spreading, bush about six feet high. The clusters are large and somewhat drooping. The fruit is large, earlier than most sorts, becoming a good red by August 19 in 1922. It made a clear brilliant jelly on that date.

The "Hahs" was selected by Mr. Hahs in 1915, but no record kept of the particular place around Lancaster, New Hampshire, from which it was secured. There are at least 18 large bushes six to eight feet high. Nearly all bore well in 1922. The clusters and fruit are of medium size and the berries color up and ripen in September at the same time that most other sorts ripen. It was selected because of the vigor of the bushes, its productiveness, and its high pectin content.

The "Andrews" (Number 18 of 1917), was selected by Mr. Andrews in 1917 near the home of Bert Howe near Lancaster, New Hampshire. The original bush was eight or nine feet high and was divided into 15 plants. The number now living is somewhat uncertain as some have not come into fruiting. Two bushes bore in 1922. They are sturdy, erect growers and about six feet high. The dark green foliage is especially fine. The fruit clusters have stout stems which hold them erect. The fruit is the largest of any sort

measured, brilliant red, and late in ripening. It had the highest pectin content of any variety September 9 to 12.

For their ornamental value five others were selected, one for its very large pendant clusters, one for its yellow fruit finally turning a light red, one for its yellow banded fruit, and two for their stiff, erect fruit stems. These are all being propagated.

Experiments and observations were made in the fall of 1922 to determine many facts regarding the fruit such as the relation of the time of harvesting to the size of berries, and to the color, quality, and yield of jelly, and the difference in the product from different bushes. These experiments and observations are recorded below.

To get a record of the increase in size of the fruit from the time when the earliest sorts were ripening the counts given in Table I were made. This also shows the variation in size of the varieties.

TABLE I

Size of Fruit August 19 compared with September 9 to 12, and Size of Varieties Compared. (One-half pound of fruit of the several varieties was counted)

Variety	Number of Bush	Number berries per pound, August 19.	Number berries per pound, September 9 to 12.	Percentage increase.
(1) Andrews	66-104	...	570	...
(2)	72- 87	688	...	...
(3) Wentworth	65-105	742	635	16
(4)	51- 77	780	720	8
(5)	57-101	784	750	5
(6)	52- 92	866	760	14
(7) Hahs	60- 93	974	800	22
(8)	57- 94	1080	900	20
(9)	63-101	934	...	...
(10)	57- 89	950	...	...
(11)	53- 86	928	...	...
(12) Hahs	60- 97	...	720	...
(13)	74- 94	1148	1020	12
(14) Hahs	60- 98	...	800	...
Average number per pound		903	767.5	18

The seven varieties counted on both dates averaged 911 berries per pound on August 19 and 810 on September 9 to 12 with an increase of fourteen per cent in size. The total average increase in weight in three weeks was about 18 per cent, but ranged from 5 to 22. On August 19 number 72-87 was 31 per cent above average weight for that date, while on September 9 number 66-104 was 35 per cent above the average.

On September 9, from 57-101, 350 soft berries weighed eight ounces, while it took 400 firm berries to weigh as much. All the soft berries were heavier than water, while nearly all the firm berries floated.

Color of Jelly

Jelly was made on August 19 from the types indicated below and with results as stated. In all tests two pounds of fruit were cooked with one pound of water. After boiling and straining out the juice, three pounds of sugar were added to four pounds of juice and cooked until a stiff jelly was formed. In late fall after the fruit is quite soft less water need be added and probably more sugar, as acid seems to develop in the ripening of the fruit.

Arranged in sequence by color values from colorless to deep red.

1.—66-106—clear.
2.—57- 94—cloudy amber.
3.—63-101—slight red.
4.—60- 93—beautiful red.
5.—53- 86
6.—65-105—beautiful red.
7.—51- 77—darkest red of any.

Jelly made from the above September 9 to 12 was a handsome red in color. That made from fruit of 66-106 was the lightest red of any but very attractive, while that from 51-77 was the deepest red. By September 9, the fruit of all varieties had turned at least a light red and fine colored jellies were made from all varieties tested on this date.

Flavors of Jelly Made August 19 Compared With September 9 to 12.

Jelly was made from four varieties on both the above dates and compared as follows:

————....66-106	On August 19, no distinctive flavor, good sweet jelly.
	On September 9 to 12, delicate viburnum flavor, good.
Hahs.......60- 93	On August 19, some viburnum flavor, but rather faint.
	On September 9 to 12, good flavor.
Wentworth..65-105	On August 19, fair viburnum flavor.
	September 9 to 12, strong viburnum flavor.
-————....51- 77	On August 19, fine flavor—not strong.
	September 9 to 12, acid, some viburnum flavor.

In general, the characteristic viburnum flavor had not developed to any extent by August 19 and the jelly was not as firm as on September 9 to 12. At the latter date the flavor was quite pronounced.

Firm Compared With Soft Fruit for Jelly Making

Jelly tests were made of soft and firm berries picked from the same bush, as follows:

57-101. There seemed to be no difference in flavor between jelly made from firm and soft fruit picked the same day September 9 to 12, from the same bush.

"Andrews," 66-104. There seemed to be no difference between jelly made September 9 to 12 from firm fruit and that made

November 3 from soft fruit which had been picked and stored since September 12.

Fruit and Stems Compared With Fruit Only for Jelly Making

A jelly test was made to determine the advantage of picking the berries off the stems as compared with cooking stems and berries together.

"Hahs" 60-97 was used. No difference could be detected in the flavor of jelly made from berries picked off the stems and those cooked with stems on. There was some difference in aroma, however, a stronger aroma coming from those cooked with stems.

Long Compared With Short Cooking

Recipes for making jelly have stated that the berries should be boiled for five minutes or until the berries burst. To test this fruit of "Hahs" 60-97 was used, jelly being made from one lot of fruit after boiling five minutes and from another lot after boiling 20 minutes. No difference in flavor of the jelly could be detected.

First Extraction Compared With Second and Third

To determine how jelly made from repeated extractions differed, fruit was boiled five minutes for the first extraction, five minutes for a second extraction, and five minutes for the third. Number 57-101, Wentworth 65-105, Hahs 60-97, and Hahs 60-93 were used. Jelly made from the first extraction of juice was most acid; that made from extraction after the first has much less acid than that from the first extraction and also has a decreasing amount of viburnum flavor. The use of soft fruit seems to exaggerate these differences. If second and third extractions are to be made they should be combined with the first.

First Extraction Compared With all Three Combined, Each Boiled Five Minutes

Hahs 60-93 was used for this test. Very little difference could be noted in jelly made from one extraction and that from the three combined. It seemed to some who tested the products that the three extractions combined yielded a slightly less acid jelly than the one extraction.

Quality of Jelly From Different Varieties

Very little difference could be detected in the quality of jelly made from the different varieties. Tests will be continued to determine this.

Quality of Jelly From Mixed Varieties

In order to have a quantity of jelly of uniform flavor to be used as a standard, the fruit from thirty or more bushes of different types was cooked together and jelly made from the extraction. This product proved to be of high quality, in color and flavor equal to the best.

Quality of Marmalade

Marmalade was made from the residue of the previous test. As there was less acid in the pulp after one extraction of juice had

been made, about one pound of sugar was used to two pounds of the pulp. The marmalade was of good color and flavor and seemed to be a desirable product. About a jar of marmalade per pound of fruit was secured from the pulp.

ACIDITY TESTS

Mr. C. A. Magoon of the office of Horticultural Investigations made acidity tests of the juice of several varieties, cooking one pound of berries in 500 cc. of water, boiling five minutes except where noted, and straining through absorbent cotton. Five cc. of the juice was used with one-tenth normal alkali to determine the relative acidity of the varieties. The results are given in Table II.

TABLE II

Relative Acidity of Varieties Expressed as Alkali Necessary to Neutralize

Varieties		*Average Alkali* September 9 to 12	*Average Alkali* November 4
Andrews	66-104	5.15	6.8
	60- 95	....	7.7
	57- 89	5.45	...
	66-106 (12 ounces berries)	6.25	...
Hahs	60- 92	6.15	...
"	60- 92 (10 minutes)	6.35	...
"	60- 96	....	8.1
	57-101	6.35	...
	74- 94	6.45	...
	74- 94 (10 minutes)	7.00	...
	57- 94	7.1	...
Wentworth	65-105	7.35	...

The Andrews which ripened latest had the least acid, while the Wentworth which ripened first had the most. The Hahs, a late ripening sort, was intermediate, but had less acid than most of those tested. The tests on November 4, were made with fruit picked September 12, shipped to Washington, and placed in cold storage. Their higher acid content indicates that acid develops in storage.

PECTIN TEST

Pectin tests were made by Mr. Magoon at the same time as the acidity tests and from the same material. The pectin was precipitated by alcohol, dried on filter paper and brought to Washington to be weighed. To 175 cc. of 95 per cent alcohol 25 cc. of juice were added, the graduate shaken, the pectin allowed to rise, and filtered through filter paper. The results follow:

TABLE III

Pectin Content of Varieties in Grams.

	September 9 to 12	November 9
(1) Andrews 66-104	1.526	1.347
(2) 66-106 (Special)	1.526	.....
(3) Hahs 60-96	.....	1.515
(4) " 60-92	1.499	.....
(5) " 60-92 (10 minutes)	1.491	.....
(6) 57-94	1.469	.....
(7) 57-101	1.450	.....
(8) 57-89	1.401	.....
(9) 74-94	1.386	.....
(10) Wentworth (65-105)	1.321	.....
(11) 74-94 (10 minutes)	1.302	.....

The Wentworth variety ripened among the earliest, making a fine colored jelly in mid-August, and is shown here to be the lowest in pectin. The Andrews and Hahs are late in ripening and are two of the three highest in pectin content. The other variety high in pectin is 66-106, the fruit of which was yellow in August and only partly colored by the middle of September.

Amount of Jelly Per Pound of Fruit

Many records of the amount of jelly secured from a given quantity of fruit were obtained, but as no satisfactory mashing utensils were available the tests do not give the maximum yield possible in the home. In making individual tests with three extractions two and one-half glasses of jelly were usually obtained.

(a) On September 12, 15½ pounds of berries were cooked with 7¾ pounds of water. About eight pounds of juice were secured; six pounds of sugar were added and 15½ jars of jelly secured. Two jars were filled with skimmings. The residue was pressed through a sieve and six pounds of pulp for marmalade were obtained.

(b) From a second lot of 15½ pounds made as above on September 12, 12 glasses of jelly and about 15½ glasses of marmalade were secured.

(c) On November 3, from one pound of Andrews, held in storage since September, two and one-half glasses of jelly (equal parts sugar and juice were used) and three-fourths of a glass of marmalade were made from one extraction.

Some observations have been made on the cultural requirements of the viburnum and notes on the various operations are recorded here.

Propagation

Selected bushes may be propagated by hardwood or softwood cuttings, layering, or division of the crown.

Hardwood Cuttings: Mr. Morgan grew many hundreds of plants from hardwood cuttings taken from the selected wild bushes. In the fall of 1922, hardwood cuttings of certain of these selections were made, buried during the winter, and in spring placed in sand in a propagating frame. About one-third grew and by fall well rooted plants four inches high were secured. Plants after three

years' growth from cuttings at East Lee, Massachusetts, were three to four feet high.

Softwood Cuttings: No tests have been made with softwood cuttings. However, when visiting the Vanicek Nursery at Newport, Rhode Island, August 21, 1923, propagation by means of softwood was observed. Plants from cuttings were nearly two feet high at the end of the second year.

Layering: Canes may be bent over and covered with soil in the spring. Well rooted canes for lining out in the field can be secured by autumn.

Division of the Crown: When Mr. Morgan secured the selected bushes from the wild he divided the crowns and made a large number. For example, of the sort designated as Howe, he made 20 plants. One (number 7 of 1917) secured from Secretary Weeks' place on Prospect Mountain, New Hampshire, was divided into 107 plants. Number 25 (of 1917) was divided into 52 plants. Under cultivation, however, this method is not likely to be used as other methods of propagation offer more promise.

Seed Propagation: In nursery practice where this plant is used as an ornamental, all nursery stock is commonly grown from seed. Seedling plants in fruit observed at the New York State and the North Dakota Experiment Stations this year, were not all alike. Observations on seedlings in the wild show variation in many characters so that it seems certain that seed propagation cannot be used when a type with certain fruiting characteristics is desired. On the other hand, it is certain that seed from selected varieties is more uniform than that from mixed sorts. For example, at the Maine Experiment Station in 1921, in looking down the rows of seedlings it was very evident from the change in the autumn coloration of the foliage just where one lot ended and the next began. The fact that one lot only and nearly all of that one lot of seedlings at the North Dakota station, was winter injured, furnishes additional evidence.

Soil and Moisture Requirements

Little is known about the soil and moisture relations of this fruit. In the wild the plants seem to grow on soil types ranging from gravelly loam to muck and clay. The soil may be acid peat in which cranberries grow, or upland on which no ericaceous plant is to be found. Under garden conditions it seems to succeed on all types of soils.

In all cases where this viburnum occurs in the wild it seems to be in locations where the soil is moist most of the time. It is commonly found along streams, in swamps, and in stone walls where the stones protect the soil from drying. Mr. Morgan suggests that the reason for its occurring in such locations is that the seed takes two years to germinate and must be kept moist during that period. Furthermore, the seedlings are especially tender during their first season of growth and cannot stand drought. When planted on a dry gravelly knoll where many kinds of plants thrive the viburnum makes little or no growth and eventually dies.

Cultural Requirements

Planting Distance: The plantation at East Lee is set six by eight feet. Our experience, so far, indicates that for orchard planting eight by eight feet would prove more suitable than six by eight feet. Many of the bushes are now eight feet high and have a spread of six feet. It is possible that with more experience we will find eight by ten feet more desirable.

Cultivation: To test the effect of cultivation a part of the plantation at East Lee was left in sod and the rest given intensive cultivation. Plants left in sod made practically no growth even where heavily fertilized in early spring. The effect of the sod was comparable to that of sod in currant plantations where little new wood is produced and, after a few years, the plants die. The part given clean cut cultivation throughout the growing season has made good growth during the past three years and has begun to fruit.

Fertilizers: Plots to which medium and heavy applications of nitrates, potash, and acid phosphate, have been given in early spring, have showed no gain over checks.

Pruning: Very little pruning has as yet been given as the plantation is young and no recommendations can be made.

Conclusions

Our work thus far has indicated that the viburnum may be grown on any garden soil if given clean cultivation. Though old bushes in the wild may yield a bushel of fruit, our plantation is too young to demonstrate how much may be expected from a given area. The bushes are especially variable in the time of ripening their fruit and in the manner in which the clusters are borne, whether erect or drooping. There seems to be a difference in size of cluster, size of berry, acidity of berry and in pectin content, though these may be greatly affected by the time the variety ripens. Viburnum jelly is considered equal to, or superior, to all other jellies, by a few, and is liked by about 50 per cent of those who test it, while about 50 per cent consider the strong viburnum flavor objectionable. The viburnum flavor is modified by combining with the quince, or by using the berries before they soften, the earlier they are used before they soften, the less pronounced the flavor, at least, to a certain extent.

The hardiness of this fruit, its pectin content, and the color of the jelly made from it combine to make selected strains of it of considerable promise as a jelly fruit in northern regions with severe winters.

How to Stage a Landscape Demonstration

By F. A. Aust, *University of Wisconsin, Madison, Wis.*

A LANDSCAPE demonstration to be successful must lay special emphasis upon the following factors: first, the practicability of the solution of the problem; second, fitness of the material selected for use in the problem; third, the desirability of having the serv-

ices of a landscape architect; fourth, that the cost of such improvement is usually within the reach of those who should have the services of a landscape architect; fifth, it must create a desire for like work. Obviously, practical utility and aesthetic utility are of prime importance and the other factors are secondary.

In Wisconsin, we are thoroughly wedded to the intensive type of demonstration work. The major portion of the extension work is done in three or four counties in which an intensive program is launched. Such time as remains is spent in other sections of the state along lines which do not need such intensive effort.

Intensive work is only staged in a county where there is a county agent. In no case is work undertaken in the county unless there is a call for this type of work coming from the people in the county through the county agent. From the inception of the demonstration to its conclusion, the county agent is the man through whom the landscape specialist works. Three or four farms are selected in each county in consultation with the county agent. The owner pledges himself to spend a definite amount of money for plant materials, in most cases not to exceed $20.00 per year for three years, and to do the planting and the necessary maintenance work. The planting plan and the superintendence of the planting are furnished by the Department of Horticulture.

The development work is usually spread over a period of three years rather than attempting to finish the work all in one year. In some few instances where new construction and new grading work have taken place, all of the planting is completed in one year. The advantages from the farmer's standpoint seem to be in favor of a three year planting program rather than the one year plan. This is especially true in the northern states where fall planting is not practical.

Besides this intensive work on the home grounds, a lecture tour is planned with the county agent the first, second and third years. During the first year, the lectures are of a general nature, dealing with rural and civic improvement, with the establishment of county and township parks, preservation of natural scenery and setting aside of lake margins, planting of roadside trees and the like. This lecture work immediately results in requests for future development plans in one or more lines. Usually one or more school grounds plans, one or two wayside park projects, perhaps a roadside planting project, and in some cases, a farm woodlot project, are then undertaken in connection with this intensive work.

If there is an active County Rural Planning Committee (a political organization, consisting of chairman of the county board, chairman of the county road and bridge committee, superintendent of the schools and two other members elected by them) usually the intensive work in the county will include the projection of a county rural improvement plan. It is very easy to develop such a plan after spending two or three years in the county with the county agent and in traveling the circuit of these various demonstrations.

The work in connection with each demonstration in the county usually is taken up in the following order:

1. Survey of the tract and consultation of the person in charge.

2. Development of the complete design and planting plan and blue prints of same.
3. A lecture tour at which time the various cooperators are consulted regarding the developed plan and the placement of the orders for plant materials and plans made for spring work.
4. The ordering of these materials for the cooperators, preferably from local nurseries, if local nurseries will give special prices for quantity orders, otherwise, they are ordered in the open market and very often wholesale prices are secured for the cooperators.
5. A trip to the county sometimes between the first of April and the 20th of May at which time superintendence is given for all of the demonstrations in planting. (Before pictures are taken). The county agent usually arranges for group meetings at these different demonstrations and a talk is given explaining the various points involved in the development of the plan, selection of plant materials and planting of same.
6. Tour of inspection and pictures of the progress of the work. About this same schedule is followed for the next three years.

Follow-up work is very important. Although the work is never paternalistically undertaken, it must be paternalistically carried on until success is assured. In connection with the follow-up work in the counties where work is completed, a Home Grounds Beautiful contest is staged and other types of educational work are initiated in the way of exhibits, newspaper articles, bulletins and the like, for the furtherance of the purposes of the demonstration. Often, later follow-up work is necessary such as pruning demonstrations, and teaching the proper care and maintenance of a landscape demonstration.

The value of this intensive type of work is clearly demonstrated by the fact that in many instances during the summer months, when the demonstration is in its height of bloom, 50 to 100 people have been known to visit such demonstrations on a single Sunday afternoon. In most of the successful farm home grounds demonstrations, the farmers or their wives really become extension workers because of the great number of requests for information concerning this work which come directly to them.

The greater the number of demonstrations of the different phases and types of landscape work in the county the greater will be the contagion spread within the county for the improvement of rural conditions.

How to Stage a Landscape Demonstration

By F. E. McCall, *College of Agriculture, Raleigh, N. C.*

PROBABLY no line of agricultural extension projects offers such possibilities of successful completion as do landscape demonstrations. This is especially true in North Carolina where there is such an abundance of available native plant materials.

In staging landscape demonstrations our policy has been to select some home, school, church, park, or other project of some community interest, and where the parties in control are willing to carry out the details of the project. The major demonstrations this season have been centered on some consolidated school grounds where the whole community had this interest.

Arrangements were made with home and farm agents to carry on home and school beautification campaigns in their county.

These local agents arranged with the school authorities to clean up and beautify the grounds about a new consolidated school in the county. The landscape specialist was then called in and a workable grounds plan was drawn to scale showing the various playgrounds, drives, walks, service and planting areas. This suggestive outline plan was agreed upon by all concerned and a final draft was completed, copies being made for the school authorities, the county agent, and the landscape specialist.

In order to get the project completed the community is called on to carry out its provisions. In most instances very little cash has been available and the project could only be done with local labor and materials.

The plans are characterized especially by the following features:

1. Use of native trees and shrubs, or exotic plants brought from the homes in the community.
2. School grounds divided into definite playground areas.
3. Well ordered drives, walks, service areas, gardens, etc.
4. Colorful borders of shrubs and flowers.
5. A good lawn area directly in front of the building.
6. Suitable foundation plantings.
7. Abundant shade.
8. Propagating garden for flowers and shrubs.

The project has been carried out largely in what we call "community planting bees" or arbor days in which each pupil and patron of the school plants some permanent tree or shrub. On this day road building machinery and tools are brought to grade the drives and smooth the lawn. Leaf mould and barnyard manure are brought for the roots of the plants. The planting areas are broken up and fertilized and the plants put in the places called for in the plans.

In many instances each class assumes responsibility for a certain tree, group of trees, or a section in the shrub border. The plants are set out and cared for by the pupils. If the plants fail to live they are to be replaced by them. In this way not only are the plantings complete, but considerable competitive pride is taken in their upkeep.

On the school grounds the plantings are massed about the borders and the foundation of the buildings with definite shaded areas.

So far the planting bees have been very successful.

One Specific Instance

At Middlesex, Nash County, arrangements were made to beautify the grounds about the new consolidated school. Ground plans were perfected early in January, 1923, and the drives were laid out at once. A general planting day was arranged for and some plantings were made at this time, but owing to the late season many of these died. The community undaunted by these failures became more determined than ever to finish the job. Accordingly another day, November 14th, was set aside. At this season plants stand a better chance to thrive than when transplanted in late spring.

The plan was analyzed and the numbers of each kind of plants were determined. The community was then organized and committees were placed in charge of trees, shrubs, leaf mould, smooth the lawn areas and plant the grass, barbecue, entertainment.

On the morning of November 14, about 450 pupils and teachers and 300 adult patrons of the community were on hand to plant their trees and shrubs. The ladies were there with their basket dinners and ten pigs had been barbecued. All were earnestly at work planting trees and shrubs in their respective positions nearly all the day. The principal of the school, the agricultural instructor, the county home demonstration agent, and the state landscape specialist, were all on hand to direct the plantings.

In all about 950 plants were set in the ground. About 700 of these were native and growing in the vicinity. They included such kinds as cedar, oak, white dogwood, wahoo, American holly, wax myrtle, azalea, maple, walnut, wild cherry, rhododendron and yucca. Large quantities of crape myrtle, lilac and spireas were also brought. Forty-two varieties of shrubs and trees were planted and about 50 roses of various sorts were placed in a rose garden.

The plantings were not completed, but a splendid start was made. However, plans have been completed whereby planting days will be held one day each month during the winter. On this day each pupil will be asked to bring a plant and place it in the group set aside for his grade. By spring the plantings will be fairly complete. At least each area set aside for plantings will be well started with plant growth. Should this plan be carried out for two or three years the plan will be complete and the pupils can then carry the surplus plants to their homes.

To date six planting bees have been held with a total planting of 400 trees, 2600 shrubs and about 50 or more bushels of bulbs besides hundreds of roots of perennials.

This project does not stop with these planting bees, as we plan to follow them up twice each season to instruct as to their pruning, fertilization, possible changes, additions and the like. We regard this follow-up as the most necessary part of the projects.

How to Stage a Landscape Demonstration

By H. H. Cornell, *Iowa State College, Ames, Iowa*

THE Extension Service in Landscape Architecture at Iowa State College is comparatively new. Therefore, good examples of work completed are rather few and scattered. A demonstration meeting conducted at one of these demonstration locations, whether a residence, farmstead, school or park, is a simple problem, compared to those numerous demonstration meetings necessarily held in localities where the advantages of actual examples do not exist. It is this latter type of demonstration meeting I wish to talk about.

In every problem in landscape architecture, it is the "plan as a whole" we must first consider. We are more concerned with the effectiveness of the complete picture we are building than we are with the improvement of any one object as a part of the scheme. The extension worker may visualize the finished scheme and be the more interested in the realization of each detail because of it, but he cannot expect his audience to warm to the problem unless they too are given a glimpse of the goal. Therefore, the first half of the demonstration might concern itself with a careful presentation of the problem as a whole, including the reasons for a complete plan and the advantages of using that plan over a period of years. Whether the meeting is concerned with the town lot, the farmstead, or the school, the suggestions given should apply directly to some property within the locality reasonably well known by everyone present. The development of the plan may be presented by the use of a blackboard or heavy drawing paper upon which the specialist may already have outlined dimly the general lines of the plan in such a way that he may only have to retrace them during the course of the talk. (A bit of humor at this point may be out of place, but more than once the writer has posed as an excellent chalk talker through such a tracing process, explanations to the contrary).

Even students in high school seldom fail to understand the characters used. They will appreciate not only a well planned, easily accessible bus court where the school busses are loaded, but will in addition appreciate the relation of the bus court to the plan as a whole. The general plan so indicated is necessarily simple but it has given the extension specialist an excellent opportunity to present the more important principles of landscape architecture as they apply to the specific problem in hand.

The last half of the meeting is conducted out-of-doors where the more important points of the plan in mind are indicated directly on the ground. Perhaps the chalk talk can be called the theoretical phase of the meeting while the out-of-doors meeting may be called the practical phase. In the latter, it usually is impossible to demonstrate or indicate on the grounds the general scheme as a whole. For example, it has been found unsatisfactory to indicate on the grounds the location of various units within a farmstead plan, the buildings, garden, orchard, and so on. The

owner himself would be the attentive part of the audience. The drawings, however, should have indicated the general plan.

A part of the plan may be successfully demonstrated on the grounds. Emphasis should first be placed upon the open lawn, the foreground of the picture. The cluttered and untidy appearance of so many lawns may be demonstrated by pointing out the usual locations of showy flower beds and freak plants and the part they play in destroying the existing naturalness of the site. A few pointers on the importance of the establishment and maintenance of a lawn may be stressed at this time.

Walks, drives, and fences, and their relation to lawn and planting may be indicated by means of stakes. The location of shade and ornamental trees may be easily shown by means of stakes. In emphasizing the importance of mass planting the outlines of a shrub may be shown by means of stakes, a rope or a trench, each plant represented by a stake, the reasons for variation in height explained at the same time. Actual planting methods in many cases seem to be a revelation to most people, and could be emphasized at this point.

To me this program has always proved reasonably successful. Actual methods used may vary and will depend largely upon the specialist. It should be of special significance to note that a demonstration of this type can be carried out at any time during the year with reasonably good weather, and to my mind this is very important as landscape work in this state must be carried on regularly throughout the year.

How to Stage a Landscape Demonstration

By H. W. Harvey, *State College of Agriculture, Athens, Ga.*

As all work of the specialist is in cooperation with the county agents, the manner of staging the demonstration depends, to a large extent, on the plans of the agent.

More often than we wish a home ground is planned with no one but the owner and the agent present to hear the discussion of the plans; but, wherever possible, neighbors are invited to come to hear the discussion and see the plans.

Some specific demonstrations are as follows: In Burke County the women of the club had been invited to meet at a farm house where the grounds were being planned. With the plan completed, the specialist discussed the fundamental principles of home beautification, the value of the open lawn, the placing of trees where shade was needed, the planting of shrubs at the bases of the buildings and at the borders, where to use trees and shrubs for the purpose of screening unsightly objects, such as barns, outhouses or undesirable views, and the plants to use.

The arrangement of walks and drives with regard to convenience as well as attractiveness, methods of construction and materials to use with a view to holding down expense as much as possible were

mentioned. Then questions were answered on how, when and where to get plants, in general or in particular, or what methods were best to use in transplanting trees and shrubs from the woods, and on the best grass to use for lawn as well as the methods of establishing it.

In Gwinnett County, plans for school grounds at Lawrenceville were talked over with members of the board of trustees, of the Parent-Teacher Association and the superintendent of the school. The plan was also explained to the whole school, with the object in view of enlisting the interest and cooperation of the pupils as well as the parents and teachers.

Other plans for public grounds are discussed with committees of various organizations. Some county official is usually interested in courthouse ground beautification; so too are the farm and home demonstration agents and the civic committee of the Women's Club

In order to insure the carrying out of plans and to eliminate requests coming from people who are asking for help simply because a neighbor has done so, the county agents are being asked to fill out in triplicate the following agreement:

> Recognizing that through the .... agent ...... secure the services of the extension Landscape Specialist of the Horticultural Division, Georgia State College of Agriculture, in planning ....grounds as a community demonstration, ...agree with the help of ....agent to follow the Specialist's plans and suggestions, to accomplish a ....part of the work each year until the work planned is completed and to make no changes without consulting the Specialist. A map drawn to scale of one-sixteenth inch to one foot, giving accurate measurements and all permanent features, is ready for the Specialist.

One copy of this agreement is kept by the applicant, one by the county agent and the third sent to the specialist constitutes an application which he can file. It is hoped that by eliminating those who are disposed to take help, "keeping up with the Joneses," only to cast it aside because it has cost nothing, more time will be available for follow-up work and the consequent improvement of the demonstrations.

Extension Work and Methods in North Carolina

By C. D. MATTHEWS, *College of Agriculture, Raleigh, N. C.*

HORTICULTURE ORGANIZATION IN NORTH CAROLINA

IN many of our institutions horticultural work is divided into three separate departments, the experiment station or research, college or resident teaching, and the extension division or extension work. In North Carolina these three are combined into one divi-

sion and their activities are closely correlated to carry out a definite program. It is recognized that the three branches of station, college and extension have three separate functions to perform, but that each can conduct its activities best when closely coordinated with the other two. It has been further recognized here that the activities of each should be very closely coordinated to conduct the strongest program of horticultural development, education, and leadership in the state. Such an arrangement places upon extension workers the responsibility of conducting horticultural education throughout the state, and of exerting leadership in the development of horticultural industries.

The Division of Horticulture has four men engaged in horticultural extension work, one conducting general work in the eastern half of the state and another doing similar work in the western half. A third worker has charge of home gardening and home beautification throughout the state, and the fourth worker is a specialist in development of sauer kraut factories and the other phases of this particular business. The activities of these specialists are directed by the Chief of the Division of Horticulture.

General Conditions in North Carolina

Changing agricultural conditions in North Carolina are causing entirely different conditions to exist in the field of horticulture. The greatest interest in both commercial and home horticulture that has ever existed in the state has resulted from the operation of existing agricultural conditions in the state and conditions in horticultural industries which include the general economic need for diversification, boll-weevil conditions, and a realization of the advantages of the state for different horticultural crops.

This increased interest has resulted in the largest demand ever made on the Division of Horticulture for extension work. North Carolina is primarily a cotton and tobacco state, these being the two chief money crops. Until the last few years the state has not been affected by the boll-weevil, but with the coming of this insect the cotton sections of the state have become interested in devloping those horticultural industries in which they have exceptional economic and natural advantages. At the same time the program for diversification has been bearing fruit to the extent that other sections are becoming interested in diversifying and they have also realized their horticultural advantages. This has placed a tremendous burden on the horticultural extension workers; at the same time offering an exceptional field for service and an opportunity for accomplishing worth-while results.

Variety of Natural Conditions in State

North Carolina is particularly adapted to horticultural development. Few states have a more generous combination of natural and economic advantages for the development of both home horticulture and horticultural industries. As an indication of the wide variation in altitude, the numerous soil types, and the varied climatic conditions, the wide range of native flora is mentioned. A survey of the native fruit bearing plants of the state shows 18 families, including 39 genera, and upwards of 330 species.

No state in the Union offers a broader or more complete field from a trucking standpoint than North Carolina. The various climatic conditions, ranging from that of subtropical in the east to almost Canadian conditions in the mountainous sections in the west, give to North Carolina an interesting and favorable place in the vegetable growing industry of this country. The high, cool mountain regions are well adapted to growing late vegetables for home and southern markets; while the Coastal Plain Section, with its level, mellow, sandy loam, easy of cultivation, and retentive of moisture, is adapted to the production of early vegetables for northern markets. With these unsurpassed natural conditions and the use of frames covered with cloth or glass, and in some cases the installation of modern steam-heated greenhouses and irrigation systems, the trucking industry has made wonderful strides, the production of vegetable crops in winter and early spring being conducted with great success.

Because of the varied climate, ranging from the mountains, with white pines, hemlocks and firs, to the lower edge of the Coastal Plain Region where we come within the northern limit of the forest growth of palm trees, North Carolina has an unusual variety of fruit growing conditions.

With figs, peaches, grapes, strawberries and dewberries among the fruits; pecans among the nuts; and Irish potatoes, sweet potatoes, lettuce and many other vegetables among the truck crops for the eastern part of the state; ranging through to apples, peaches, grapes, and Irish potatoes in the western part of the state; together with a growing season of 180 days in the mountains and one of 250 near the coast, North Carolina offers a varied field for extension activities.

Determining Extension Problems

In developing its horticultural program the Division of Horticulture through the survey method has made an earnest effort to determine the most important problems in horticulture in the state, so that the horticultural extension work could be organized on a logical basis and so that the maximum amount of service could be performed. A very careful study of the horticultural development and possibilities of the state has been made to determine the commercial and home problems.

The commerical interests of the state have been studied from the viewpoint of the problems of existing industries and from a standpoint of the development of new industries for which certain parts of the state have special natural and economic advantages. Similar study has been made with the home aspects of horticultural extension.

In developing this program it has been fully recognized that the success of extension work depends upon determining the real problems of horticulture, the soundness of principle on which the work is conducted and the degree of efficiency developed in presenting the work and that a measure of success is the extent to which the teachings of the demonstration are adopted in a community.

Organization of Work

After determining the commercial and home problems, a definite and logical program for horticultural extension combining definite objects to be accomplished with definite plans of work has been developed on the project basis. This program is divided into commercial and home phases.

We have found in the organization of demonstration work, that the definite project plan and program basis is the most satisfactory system. A descriptive list of horticultural extension projects is sent to each county and home agent every fall in time to allow them to select those projects best meeting the needs of their county so that they may be included in their plans of work for the coming year. At the county agent conferences of the different districts the scope of the different projects is explained in detail as is the manner of conducting them. The agents submit their program for horticultural work to the specialists and a cooperative program between the agents and specialists is worked out and any readjustments necessary are made so that a definite year's work is planned with certain objective points and methods of attack fully outlined. Time does not permit the giving of details in connection with all phases of the work and it is the intention to bring out only the more important parts of the work that is conducted in the state.

Agencies Employed

It has been the aim of the extension workers to make contacts with, and to make use of, every agency that might be of value in connection with their work. Of course, the county and the home demonstration agent organization is the most important. The success of the work very largely depends upon the county and the home agents. Our work has naturally developed along commercial horticulture and home horticulture with most of the extension work in commercial horticulture being done in cooperation with the county agents and home horticulture in cooperation with home agents. Contacts include cooperation with chambers of commerce, railroads, civic clubs, cooperative marketing associations, other state departments, such as the Department of Education, State Board of Health, and other divisions in the college. Extensive use is made of all types of publications such as newspaper stories, mimeographed articles, circulars, bulletins and posters.

Activities

The extension program is divided into commercial and home phases with projects under the heading of commercial projects in orchard management, sweet potato storage, sweet potato cultural practices, sweet potato seed selection, Irish potato seed development, sources of seed, and from a home standpoint under the headings of home garden, home orchard, and home beautification. All of these projects have been developed and organized under the general system as outlined.

It is not the intention of this paper to supply details in regard to each of these projects, but a detailed description of several pro-

jects will certainly bring out clearly the nature of the work in the state and the methods employed.

COMMERCIAL PROJECTS

Orchard Management: A survey of the apple industry was made with the idea of finding out the limiting factors in apple production. The last census showed a large number of bearing apple trees in Western Carolina and also brought out the fact that the average production of these trees was very low for the same year when commercial orchards that had received good attention were yielding from 1500 to 3000 per cent more fruit than the general average bearing tree. A study of this condition revealed the fact the difference in production was due to the pruning, spraying and orchard management that the different trees received. It was thus established that the limiting factors in apple production for North Carolina were the ones of orchard management, pruning, and spraying. Consequently, definite projects and definite demonstrations dealing with orchard management, and with pruning and spraying, were drawn up and have been conducted in cooperation with county agents. This work has been extended to the large farm orchard with good results. The results secured at Hendersonville in Henderson County are illustrative of the effectiveness of this work. In this demonstration part of the orchard was treated by giving light dormant pruning, nitrate of soda, cultivation, and six sprays.

The untreated portion of the orchard received no pruning, fertilization, cultivation, or spraying. Several forms or records were secured on this demonstration. The information secured was brought to the attention of fruit growers in several different ways. An orchard meeting was held in connection with the harvesting of the plots. News stories of the results were given wide circulation. An effective presentation of the results was made at the State Fair where the fruit from a tree of each plot was properly labeled and placed on exhibition. The exhibit brought out the fact that the trees were Winesap 20 years old, had set a heavy bloom and the two trees were 25 feet apart. The exhibit presented the fact that the treated tree yielded 18 bushels of remarkable apples and 3 bushels of culls, while the untreated tree gave a total yield of one-fourth bushel of culls.

Irish Potato: With Irish potatoes a survey of the industry showed that many cars of northern seed were used annually in the eastern part of the state to produce the truck crop that is harvested and marketed in June. There has always been some dissatisfaction among the growers in regard to the seed. Investigation work conducted by the Experiment Station had brought out in an experimental way that superior seed could be produced in the higher elevations in the western part of the state, and that this seed was valuable for use in Eastern Carolina. Because of the demand for seed and the results of the experimental work, the seed potato industry has been developed in the western part of the state. The extension projects with Irish potatoes consists of three phases; first, the development or seed growers cooperative associations in the western part of the state; second, the development of the in-

spection service for seed potatoes; and third, the demonstration of comparative value of Western North Carolina seed with that of northern seed for Eastern Carolina. In organizing the seed potato growers association, a membership of nearly 300 growers was secured on the contract basis. Inspection service was developed whereby three field inspections and one bin inspection were given to fields entered for certification. Demonstrations have been conducted in Eastern Carolina to determine the comparative value of Western Carolina seed and northern seed. The demonstrations during the last year showed that the mountain seed outyielded the northern seed on an average of 24 bushels per acre.

Cabbage: Another example of the type of work developed by the extension service is the cabbage project. Work consists in the organization of cabbage growers associations, the construction of kraut factories, the giving of demonstrations, and the supplying of information in regard to cabbage growing and the operation of kraut factories. In the extreme northwestern portion of the state is a territory which is known as "the lost provinces," because of their poor transportation facilities. There has been great need in this particular section for a money crop that was comparatively non-perishable. Cabbage grows to perfection in this elevated territory so the extension service attempted the development of the kraut business there. Very successful results followed the beginning of the project from the standpoint of organizing, building and operating of the kraut factory. The pioneer demonstration with 90 growers in the association is located in Watauga County. Three hundred and fifty tons of cabbage have been krauted at the factory and sold through the association. The extension service through its kraut specialist has conducted the development of the industry from the very beginning and throughout its ramifications.

Home Projects

The horticultural program of North Carolina is interested in problems of home horticulture equally with those of commercial importance. Better living conditions for farm families has received our attention for some time. While the problems of commercial horticulture have been conducted largely in cooperation with the county agent, it is true that the problems of home horticulture have been more especially handled in cooperation with the home agents. The extension specialists of North Carolilna are extremely fortunate in having a splendid machinery for handling the home problems in the form of the home demonstration organization. Most of the results that have been secured by the extension workers in this field are entirely dependent upon the splendid organization and functioning of the home demonstration agent system. It has been our plan as mentioned before, to logically determine what the problems are and to make a program to meet them. Then the projects were sold to the home demonstration agents and their cooperation secured. In surveying the field of home horticulture the two phases of home garden and home beautification made themselves easily apparent.

Home Garden: In the territory where cotton and tobacco were

the main crops, the one crop method of farming was largely practiced and to such an extent that most of the farmers had very poor home gardens and many of them no garden at all. In fact, the last census showed that over 40,000 North Carolina farms were without gardens of any description. It is evident that this was a vital problem for the extension service to handle so our project dealing with this condition was framed and put into practice. The garden projects offered several factors of successful demonstration. First, the food supply of the family was enhanced as regards quantity, quality and variety. Second, the garden offered products easily grown that brought in quick revenue most needed by the rural housewives. Third, a showing of definite returns, also meant the continuance of the demonstrational work.

The statistical summary of the home garden project last year showed that 163 demonstrations were conducted by the specialists.

As a result of cooperative work the home demonstration organization, 6,767 market garden and canning crop demonstrations were conducted by the home agents. This is an indication of the growth that has been made as a result of the home garden project as conducted by the extension specialist. In the conduct of the demonstration work with the home agents, especial attention has been given to training them so that they could conduct the demonstrations.

Home Beautification: A survey of the state showed conclusively that there was a splendid opportunity to make better living conditions through the agency of home beautification. A trip through any section showed the great number of tenant houses and homes without lawns or any other forms of beauty. Yet the woods were filled with an abundance of native plant material which could be had for the transplanting. At the same time it was evidenced in many ways that the people were starved for home beautification and merely needed to be led in this direction. Consequently the project of home beautification was developed. It was natural that with the splendid machinery of the home demonstration organization at hand it should be used, because the home agents naturally work more closely with the home, its improvement, beautification and food requirements. The project was outlined in a way easy to follow and offered a chance to definitely tie their work to the community for a period of years. The project gave definite opportunities for community demonstration and offered chances of immediate accomplishment and could be carried out with little cost.

The following types of demonstrations were given in cooperation with the home demonstration and county agents during the last year.

1. Transplanting demonstrations to teach the home owners how to transplant trees, shrubs and vines, especially native varieties from the woods to their yards so as to save the whole shape or frame work of the tree or shrub.

2. Variety demonstrations to acquaint the prospective planters with flower, shrub and tree varieties and their use in the landscape with emphasis on the native varieties, and improved exotic sorts.

3. Arrangement demonstrations to show how plant materials can be arranged to really enhance the appearance of the grounds and to give serviceable comfort as well.

4. Lawn demonstrations to show the fundamental principles of lawn building and maintenance by soil preparation and fertilization, and the proper seeds and seeding.

5. Engineering demonstrations to show the proper methods of drainage, yard divisions, arrangement of buildings, and the construction and maintenance of drives and walks.

6. Maintenance demonstrations to demonstrate how to properly prune, fertilize, spray, and otherwise maintain the plantings.

The county home demonstration or farm agent, or both, had previously arranged to hold a county home and school improvement campaign. The landscape specialist was then called into conference and a definite plan or program for the landscape part of this campaign was determined. In some counties community meetings were held in which the proposition was presented in detail. Then a day or so was spent in this community giving demonstrations on home, yard and community grounds planning (the latter usually school grounds). Definite plans were made to scale on a sheet of white paper 17 x 22 inches. Carbon copies were made of this plan in triplicate, one for the demonstrator, one for the county agent and one for the files at the horticultural office in Raleigh. Each plan shows in detail complete planting and arrangement. A list showing varieties suitable for each district goes with each plan and the varieties used in the plan are checked on the list.

This work offers many types of landscape improvement. Plans were prepared for 80 schools, 79 homes, 28 churches, one community park, two cemeteries, seven court house grounds, and one town community center. Rough sketches were made of 71 home grounds, five cotton mill grounds, three mill villages, and one whole town was replanned. The project calls for following up these demonstrations for two years in order that the plantings and arrangements may actually become accomplished facts.

Planting bees were arranged at each school or community demonstration at which time each pupil and patron of the school planted some permanent tree, shrub, or flower.

Much enthusiasm was aroused by the 16 planting bees conducted in early fall. They involved the planning and planting of the school grounds. The work was handled through home demonstration clubs and is done with cooperation of the home agent, school superintendent, and county school supervisors, and in many cases with the farm agent. A description of one of these planting bees is given as an interesting example of the work. One of the most successful of these was held in Alamance County. Over 600 people attended the occasion and practically every pupil and school patron brought some shrub, tree, or flower, for planting on the grounds. The plan had been previously made and each plant was placed in accordance with the plan.

At the conclusion of the work it was found that 75 trees, 450 shrubs and between 500 and 600 flowering plants had been set out.

The roads and the walks were laid out and graded and the lawn fully prepared and seeded to grass.

A special course for home agents was given during the summer at the annual conference of home agents. Seven demonstrations were prepared and presented to them in their annual state conference at Blue Ridge in early July. Each of these lessons was amply illustrated by graphic illustrations. The object was to show in at least a general way the types of plants that are most suitable for home landscape work; to acquaint the demonstration agents with the general plan of home and community landscape improvement; to familiarize the agents with the native plant materials; to show that each home is a specific problem and how best to handle it. These lessons were well received by the agents who were very attentive and many have since shown that much good was derived. The agents were particularly fitted for conducting their home beautification work as the result of courses of instruction given. As a result of the home beautification project the home demonstration organization conducted 2581 demonstrations in planting flowers and shrubs and secured 524 cooperators in planting home, school and church grounds to a definite plan. In all of this work native shrubs, trees and flowers, were largely employed.

Office Methods

This division has given considerable study to office methods under the headings of correspondence, filing, records, and bulletins, in connection with extension work. It has been the aim of the division to become as systematic and orderly as possible, believing that our work would profit if we took suggestions from large corporations in office management. These methods have been in use and have been developing for six years and have been of tremendous value to the work.

Correspondence: The system that has been worked out in handling the correspondence is worth mentioning. All of the mail is opened by the clerk, rather than having it opened by different individuals to whom it is addressed. It is then distributed to the proper workers by the mail clerk. There are many advantages of such a system. Oftentimes the worker may be away from the office for several weeks and in such a case matters are promptly handled instead of forwarding the mail to him, or holding it until he returns. Oftentimes letters come in necessitating changes in date of demonstrations and such a system allows rerouting easily and in time.

All correspondence of different workers in the division is filed in a central filing system, rather than in individual files for each worker. This filing is done by a filing clerk. In this way the entire correspondence relating to all business with an individual, or an organization, is readily accessable, and each worker easily determines the relations of the division with its various correspondents. This also makes continuity and unity in the work and develops the idea of team work and the importance of the division, rather than of any individual.

Records: Special attention has been given to the filing of

records in such a way that continuity of the work can easily be secured. Attention has been given to the matter of system in filing so that information can be quickly found.

Bulletins: Several years have been devoted to developing a system of filing bulletins for the use of extension workers. The system has been very satisfactory in that it allows workers to obtain bulletin information in a very short time. The system is readily expandible so that publications are quickly and easily catalogued as they come in. Time does not permit giving the details of this system, but it is mentioned here for the reason that it is a very important part of our extension organization, and is numbered among our most valuable tools.

CONCLUSION

Such types of work as have been described in this report go a long way in selling the agricultural service to the state and certainly develop the most loyal support on the part of the people throughout the state.

Present Status of the Farm By-Products Factory in New England

By W. W. CHENOWETH, *Agricultural College, Amherst, Mass.*

THE farm by-products factory has become an established business in New England. This line of work has been developed in comparatively recent years. Ten years ago there were not more than two or three such plants in successful operation in Massachusetts. Today there are almost 50 of them.

These farm by-products factories represent many types of activity. They range in importance (as viewed from amount of sales) from the housewife who sells a few hundred dollars worth of canned fruits and vegetables and manufactured products from her kitchen, to the well organized factory fully equipped and which markets $12,000.00 to $15,000.00 dollars worth of products.

Factories of the latter type demand the entire attention of the operator during the canning season, but leave abundant leisure during the winter and early spring. These factories as a rule offer a great variety of products, which are sold directly to the consumer. Factories of this type are not strictly a salvage proposition. They are operated largely because they are returning to the owner a fair income for labor and for the investment.

The rapid development of roadside selling of all kinds of farm produce, and the establishment of tea houses along well traveled roads, has given the managers of farm by-products factories exceptional opportunities to place their products before the public. And as a result practically the entire output of these small factories goes directly into the hands of the consumer.

Some factories have their special clientele which has been built up around the satisfied customers and those to whom they have

recommended the factory's output. These customers return each year for the family supply and in many cases it is most gratifying to note that orders are larger than for the preceding year. In not a few cases these orders are in the hands of the factory operator before or soon after opening for business in the spring. This method of sales has some advantages over roadside sales since the operator knows, to some degree at least, what he must provide for his customers.

A cooperative movement which has been carried on successfully in at least two communities seems to offer great possibilities. These two cooperative organizations are organized along marketing lines. Their attempt first is to produce a fairly uniform type of products which may be pooled and sold through one agency.

The cull apple continues to be the big problem of the New England fruit grower. The solution of this problem is being slowly worked out. One section has found the canned apple to be the solution of the lower grades. Some progress has been made in manufacturing apple butter as a possible use for the poor grades. The manufacture and sale of sweet cider is increasing and many fruit growers find this the most profitable means of marketing the culls and poor grades.

In the marketing of sweet cider some significant facts have been brought out. The fruit grower who exercises the greatest degree of cleanliness in making the cider and in its subsequent handling, has been the most successful in marketing large quantities, and in escaping painful experiences with law enforcement officers. Clean sweet cider, handled in a sanitary and legal manner, is doing much to place this product in the position it should occupy—that of the best of all fruit juices and a delicious, nutritious soft drink. Where such practices have been carried out the fruit grower has realized a good price for his culls and has helped to establish this business as a strictly moral and legal enterprise.

The consuming public is not yet ready to accept pasteurized sweet cider as a bottled drink. When consumed directly from the bottle as is the common practice of serving bottled soft drinks, pasteurized sweet cider has a foreign flavor, due to the cooking, which the average consumer does not like. Some means must be found for properly aerating bottled cider before consumption, or some changes must be made in present methods of pasteurizing, if bottled sweet cider is to become a popular soft drink. Here is an opportunity for the research man to render a real service to both the producer and consumer of bottled sweet cider. Give the cider manufacturer a method of placing his product before the consumer in such condition that its original flavor and taste are not noticeably changed, and the cull apple problem will be practically solved.

Vinegar making as a means of utilizing culls has developed mainly in connection with the marketing of sweet cider. Such cider as passes the legal standard is at once placed into barrels, set aside for the manufacture of cider vinegar. This vinegar to be marketed either to local stores, or through the medium of the roadside stand.

Interest in the farm by-products factory is growing throughout New England. Many fruit growers who were skeptical a few

years ago are now planning to do something along manufacturing lines; and at present it looks as though we shall eventually solve at least a part of the problem of "what to do with the culls and poor grades."

The farm by-products factory which was first advocated as a salvage proposition to take care of culls and low grades of both fruits and vegetables, has demonstrated to the New Englander that it may well serve this purpose. It has also shown that under efficient management it is a good business when operated purely as a business enterprise. The investment is small, the returns are quick with sufficient profit to make work of this type attractive to those specially adapted to it.

The farm by-products factory is no longer a theory. It is now an established business under New England conditions. The development during the past five years has been most gratifying and the increasing interest manifested by fruit growers is an indication that the business will continue to grow.

Cooperative Extension Work Between the College and the Producer of Horticultural Manufactures for Sale.

By W. R. Cole, *Agricultural College, Amherst, Mass.*

THE Massachusetts Agricultural College maintains a Department of Horticultural Manufactures which is constantly seeking new methods and the improvement of present practices in food preservation. The Extension Specialist is employed to carry this information from the department to the people of the state who cannot come to the Agricultural College.

When extension work in horticultural manufactures was instituted in Massachusetts, it resolved itself into offering assistance to three groups of people: first, the producer for home consumption, represented by the farm and rural community housewife; second, the farmer who is looking for assistance in manufacturing and storing his horticultural products; and third, the farm or village resident who has a greater or less amount of raw materials—fruit, vegetables or meat—for sale, and prefers to market them as a manufactured product rather than as fresh produce.

This last group also includes those people who are engaged in the canning or manufacturing of fruit and vegetable products using raw materials furnished by those for whom they do the work.

This paper is intended to discuss this third group and the relation of the College and the extension service to them and their problems. For lack of a better name they are styled "Producers-for Sale."

What are Their Problems?

The first problem of most of these people is efficient technique. Some were already producing for sale when the College first

inaugurated this type of extension work. Their gain from the extension service has been through receiving information worked out in the college laboratory. They have been made acquainted with the can-cooked method of canning, and it has come to universal adoption in place of the older open-kettle method. They have been educated to the practice of multiple extraction of fruit juices, thereby increasing the returns from given quantities of raw materials. They have learned to use less sugar in their fruit products and thus get higher fruit flavor, better quality, and more healthful products.

Others, and a much greater number, have taken up this project within the past five years. This group is made up largely of people young in the work; they have had little or not any experience with other methods, and it has been relatively easy for them to adopt those methods developed at the College.

These people have learned that in canning certain raw materials they must use all possible speed and care, while other materials may be handled much more slowly without affecting in any way the quality of the finished product. They have needed lessons in handling fruits and fruit juices for manufacturing purposes in such manner that they may get the highest quality together with assurance that their products will stand up under all conditions of transportation and storage.

Another problem confronting the producer-for-sale has been the packaging of products—the type of jar to use, the advisability of using a different package for a jam from that used for a jelly, the size package to use, the requirements of the law as to labeling, and the quantity of a given product which should be packed into each jar.

Other problems are the quantity of a certain canned or manufactured product which should be obtained from given amounts of raw materials; the time necessary, under normal conditions, to prepare a given quantity of raw materials for canning; the materials which should be canned or manufactured under the conditions of the fresh products market in effect in the community where the producer-for-sale is located; the best way to lay out or organize the kitchen or workshop to get the greatest possible ease and efficiency in production; the equipment necessary, and the minimum investment in equipment that will give the greatest production, and products of the highest possible quality.

Marketing presents a very important problem. How can one find a market? Many are in a position to make a wide range of canned and manufactured products, while others may have a special variety of raw material or a special aptitude for making a particular product.

Should cooperative marketing be attempted? Some communities have a group of individuals interested in the work who do not individually produce in sufficient volume to warrant an attempt to sell, but who might well afford to do so as a cooperative effort. Is it best to confine marketing efforts to direct sales or should retail stores, exchanges and roadside stands, be used as outlets for products? All these methods of distribution are employed,

some producers using one, while others use all. The most successful is the direct sale method wherein one satisfied customer brings a new one.

How shall the selling price be determined? Some producers have been satisfied if they received a fair return over and above the market price of the raw material, calling this return "labor income" and accepting it as profit and as wages for doing the work of production. Others figure a fair wage into production cost and fix the selling price far above the cost of labor and materials.

Should some products be marketed by one method while others are distributed through another outlet? Some producers sell all their canned products by direct sale and distribute their manufactured products through tea rooms and exchanges.

How Does the Extension Service Meet These Problems

In most instances knowledge of the existence of these problems comes to the College through the county extension service. Owing to the fact that the majority of those engaged in the work are women, most of these opportunities for service are discovered by the home demonstration agents, although the agricultural agents occasionally meet them. With those persons already engaged in producing for sale, the problem is brought to the attention of the extension service by a definite request for assistance on a specific problem. Sometimes this request is made in person or by telephone, but most frequently it is done by letter.

If the request for assistance is made personally or by telephone, the answer is immediately given, if possible. If the difficulty is such that no immediate answer can be given, it is taken up by the department staff as soon as possible and a solution given by mail, or by field visits. If the trouble is presented by mail, it is answered at once if possible, otherwise, as soon as solved.

If the person interested is new to the project, the county worker and the college specialist visit the interested party and carefully advise with him or her on the many problems incident to beginning the business. This will take more than one visit; frequently three or four are made before a definite decision is reached. The number of different products to be made is discussed. The sources of raw materials are considered; how they are to be obtained; whether or not they should be grown for the purpose of canning or manufacturing; or whether it might be best to grow for market as fresh produce and only handle through the kitchen when the fresh produce market price is too low to afford a profit. It frequently happens that one proposing to engage in production-for-sale will be able to buy raw materials more cheaply than he can grow them himself.

The location of the kitchen or workshop is selected. If a room on the premises is available, the changes necessary for efficiently carrying on the work are outlined. If new construction is necessary, plans are discussed and sketches made. The location is looked over to see where the water supply is coming from. If gas is not available, the kind of heat to be used is decided upon and the place to set up the stove is picked out. The placing of the work table

receives attention, keeping in mind a liberal assignment of space for every part of the work and a proper routing of operations so that unnecessary work will be avoided. Storage space for empty containers and for finished products is provided.

The amount of production to be attempted is figured out and the quantity of raw materials and containers necessary to reach this production is examined. The type of container to be used for each product is decided upon, after the advantages of various kinds have been investigated. This decision is made with samples of many different makes, both full and empty, at hand. Prices of these containers are later obtained by both the interested producer and the county agent. Very often the county extension service can pool orders for jars and make a very material saving for the producers-for-sale.

The labor question receives attention and if more help is to be needed than appears immediately and easily available, steps are taken to secure an adequate supply.

The marketing problem is approached by a canvass of all outlets for products and a decision is made as to how these outlets may be used, enlarged if necessary, and new ones discovered. The possibilities of direct sale, tea room, roadside stand, exchange for wholesale distribution, are thoroughly discussed, and, if possible, the method to be used is decided. If this cannot be done at once, the problem is further studied by conference with other people engaged in similar work in the immediate vicinity. If the possible production for the individual is limited, the community is canvassed for practical cooperators to build a larger output.

After all the questions and problems incident to embarking on the project have been thoroughly considered, and a decision to start has been made, the question of technique is in order. Most of those contemplating producing for sale have a good knowledge of the modern methods, for they are good members of the first group mentioned at the beginning of this paper, that is, the producers for home consumption. Problems of technique with them may be described as the adaptation of retail prices to wholesale requirements.

The county worker and the specialist advise the producer to do large amounts of canning and manufacturing by the same methods used in producing for home use. When any trouble comes up, the producer gets in touch with the county service, and if necessary the specialist is called in. The producer in many instances keeps in constant touch with the state specialist by mail, keeping him informed of the progress of the business.

The specialist carries or sends to the producer any new developments in the project. He calls to his or her attention new types of containers that may have been brought out and advises as to their adoption in the work.

During the summer of 1923, the extension service conducted eight training conferences for producers-for-sale. These were laboratory conferences held at three central points—Boston, Worcester, and Springfield—and were designed to aid the producer by helping him or her to answer certain questions of a technical

nature. Each person attending brought to the conference certain difficulties encountered in the work. These problems were attacked in the laboratory by the person bringing them in, assisted by the specialist. These conferences were in session all day, and a typical day showed ten "students" at work on 16 different products. Often the same problems were encountered in more than one product.

One of the best advertising mediums for the producer-for-sale is the fair exhibit. The specialist brings to the attention of the producers-for-sale the advantages of this type of effort and urges them to make entries. Wherever possible the producers are induced to attend these fairs and if opportunity offers, the specialist and the producers go over the exhibit and compare quality, appearance, and attractiveness of various entries.

The specialist makes every effort to get the management of fairs to create prizes for producers-for-sale and to offer adequate premiums.

What are the Results to Date

There are in the state approximately 35 people engaged in this project, with whom the College works. Their enterprises vary from one producing nothing but canned chicken to one producing for sale over 125 different kinds of manufactured products. Their individual production ranges from one who "made enough money to build a piazza," to one whose income will this year net $3,000.00.

One fair offered $200.00 in prizes for producers-for-sale; every class had more entries than there were prizes. One producer showed 500 jars at another fair and has sold over $800.00 worth of products as a direct result of that display.

Demonstration Orchard Results in Connecticut

By W. H. Darrow, *Agricultural College, Storrs, Conn.*

THE fruit program of the extension department in Connecticut is divided into nine major projects as follows:

1. Demonstration orchards in which the cooperators follow definite instructions prepared by the fruit specialist covering all of the principle orchard operations.

2. Raspberry demonstrations in which the primary object is to find out the varieties best adapted to the various sections and soils of the state. Management demonstrations are also made of each plot.

3. Strawberry demonstrations which are planned in a similar manner to the raspberry demonstrations.

4. Spray ring work which includes the organization of new spray rings in localities where needed and more or less supervision of old spray rings where necessary.

5. Fertilizer demonstrations which refer especially to the

use of nitrate of soda in sod orchards. Due to the excellent results obtained in the past two years it is planned to emphasize this project during 1924.

6. Grape demonstrations in which special emphasis is placed on fertilization, and spraying for black rot control.

7. Peach demonstrations which include spraying for brown rot and scab, fertilization and borer control by the paradichlorobenzene method.

8. Special demonstrations of all kinds which are not connected with the work in the other projects are included here such as thinning, rodent control, special spraying or pruning demonstrations, etc.

9. Publicity work which is considered one of the most important of all. It includes the preparation of numerous and timely articles for the Connecticut Agricultural College Review and for other papers reaching Connecticut farmers; circular letters which are sent out to a state mailing list of 1000 fruit growers; bulletins, several of which are prepared each year as time will permit; auto tours, field meetings, lectures, etc.

During the season of 1923 there were 49 demonstration orchards supervised in Connecticut, the smallest number in any one county being three and the largest number 12. Forty-three of these orchards came through the season successfully.

Complete records covering yields, receipts, expenses, etc., are required from each orchard. These are reported after the season's crop has been disposed of. This means that records are received from some orchards in November and December and from others not until February or March. The demonstration orchardist is responsible in each case for the keeping of the records and the returns reported by him and checked up only in a very general way.

The results obtained in several of these demonstration orchards representing various types, will be reported on here.

Orchard of Mr. A. E. Johnson, of Bethlehem

In 1919, Mr. A. E. Johnson, of Bethlehem, was primarily a dairy farmer. He kept a herd of 20 dairy cows and his total sales from fruit were $308.00. He is now spoken of as a "fruit grower". He is milking only one cow and his fruit sales for the past two seasons have averaged over $2000.00. The increased yields and sales from apples on Mr. Johnson's farm can readily be compared by his records for the past five years, which follow:

	1919	1920	1921	1922	1923
Yields, bushels	616	923	1140	2750	1941
Total sales, dollars	308	554	796	2063	1971

In 1921, one acre of Mr. Johnson's orchard, next the highway, was treated as a demonstration plot. It was fertilized, pruned, and sprayed according to the directions recommended. During 1922 and 1923, the entire orchard received the improved treatment with the exception of a one-half acre plot which was left as a check. The table above shows that Mr. Johnson's yields and sales increased

somewhat in 1921 following the improved treatment on one acre of his orchard, but more than doubled the next year when the treatment was extended to cover the balance of his orchard. The returns fell off slightly in 1923 because of the "off-year" on Baldwins.

Mr. Johnson's bearing orchard consists of 428 trees which range from 12 to 40 years in age. The demonstration acre of 48 trees on which accurate figures have been kept for the past two seasons, is about 24 years of age. The trees in this plot have received a light pruning during the dormant season which has consisted of the removal of dead branches and any small interfering branches throughout the tops. From four to five sprays have been applied each season. The fertilization consisted of eight pounds of nitrate of soda per tree in 1921, five pounds of nitrate of soda in 1922, and five pounds of nitrate of soda and eight pounds of acid phosphate in 1923. The trees are growing in sod and the grass has been mowed twice each season and allowed to remain where it fell as a mulch. The adjoining check plot has received essentially the same treatment except the fertilization was omitted and the grass was removed as hay.

The following are the yields and sales from the fertilizer demonstration and check plots for 1922 and 1923:

		Yield per acre bushels	Actual sales per acre, dollars
Fertilized Plot	1922	568	384.31
	1923	123	163.25
2 year average		345½	275.78
Check Plot	1922	144	75.60
	1923	96	78.10
2 year average		120	76.85
Gain per acre		225½	196.93

Besides the returns from his orchard, Mr. Johnson secured during the past year about $500.00 from the sale of potatoes, poultry and milk. The commissions from a butter and egg route netted him about $25.00 per week. A hay crop which was fed to young stock gave several hundred dollars more.

Orchard of Mr. C. E. May, of East Woodstock

By fertilization of his 14 year old McIntosh orchard, Mr. C. E. May of East Woodstock, increased his crop by 1.2 barrels per tree or about 70 barrels per acre. The fertilized trees yielded at the rate of 157 barrels per acre while the unfertilized trees yielded 87 barrels per acre.

During the seasons of 1920, 1921, and 1922, Mr. May was compelled to sell practically his entire crop of McIntosh for cider apples due to a severe infestation of apple scab and other pests. By following a thorough spray schedule in 1923, he produced 610 barrels of McIntosh apples practically free from defects of any kind from 220 trees 14 years old.

Mr. May's farm contains about 100 acres of land of which 10 acres are in orchard. The trees in this orchard vary from 14 to 30

years of age. Baldwin and McIntosh are the principal varieties. The yield this year was about 1200 barrels of which 610 were McIntosh, 440 Baldwins, and the rest of miscellaneous sorts.

In the fall of 1922, Mr. May was discouraged with the poor results obtained from his McIntosh trees. He even considered top-working them to Baldwins. Upon seeking the advice of the county agent and the fruit specialist he was advised to follow a different program as regards pruning, fertilizing and spraying.

Following the advice given, the trees were carefully pruned during the winter of 1922-23. This pruning consisted principally of thinning out small branches throughout the tops where they were thick and interlocking. This was done so that a more thorough job of spraying could be done and so as to allow more air circulation and sunlight to penetrate the tops.

Two or three weeks before blossoming time about four pounds of nitrate of soda and eight pounds of bonemeal were applied about each tree. One row of McIntosh and one row of Baldwin trees across the orchard were left without any fertilizers as checks, so that the value of the fertilizer could be definitely measured.

During the season of 1923, eight sprays were applied to the McIntosh trees and five to the Baldwins. Mr. May followed the regular spray schedule issued by the extension service. The grass was nowed twice and allowed to remain where it fell as a mulch.

At harvest time a record was kept of the number of barrels picked from the check rows and from the fertilized rows adjoining. The McIntosh check row of 10 trees produced 15 barrels while the adjoining fertilized row produced 27 barrels. The check row of Baldwins yielded 13 barrels while the adjoining fertilized row yielded 25 barrels. As the trees were planted 25 by 30 feet there are about 58 to the acre and the increase from the fertilizer was, therefore, at the rate of about 70 barrels per acre. The cost of the fertilizer was about $15.00 per acre. In other words $15.00 worth of fertilizer produced 70 barrels of apples in Mr. May's orchard.

While Mr. May had considered selling his farm in 1922 the farm is not on the market at present.

Orchard of E. M. Hawley, of Monroe

As a sample of the work being done with the small farm orchard that of Mr. Edgar M. Hawley of Monroe, is fairly typical. Mr. Hawley's record this year was $804.00 worth of fruit sold from a renovated orchard of 90 trees.

This is the second season that Mr. Hawley has conducted his farm orchard as a demonstration. It consists of 90 trees of which 50 are Baldwin, 20 Roxbury Russet, 15 Tompkins King and five Twenty Ounce. The age of the trees is said by the people of the vicinity to be about 28 years. (Mr. Hawley has lived on the place only 3 years). Due to years of neglect all the Twenty Ounce and many of the Tompkins King trees are in bad condition with hollow branches and trunks, collar rot and canker. The larger part of the Baldwin and Roxbury Russet trees are fairly well preserved, but previous to 1922 contained considerable dead wood and were lacking in vigor.

The trees were pruned in the spring of 1922 by removing dead wood and any interfering small branches throughout the tops. Shortly before the trees blossomed about 10 pounds of nitrate of soda were applied to each tree. The crop harvested in the fall of 1922 was very small, but the trees showed considerable increase in vigor due to the stimulation from the nitrate of soda.

In the spring of 1923, the trees were given another light pruning and about seven pounds of nitrate of soda each. A fairly good set of fruit was obtained, especially on the Baldwin trees, and at harvest time the record showed a total of 225 barrels, or 675 bushels of apples from the 90 trees. The No. 1 Baldwins were sold to a Bridgeport store for $1.50 per bushel at the farm. The Roxbury Russets brought $1.00 per bushel, and the cider stock 70 cents per hundredweight. The total sales amounted to $804.00. The total expenses for the year were $211.60 and the net income was therefore $592.40, or an average of over $6.00 per tree.

Mr. Hawley has been so encouraged with the returns from his 90 tree orchard that he intends to renovate the 40 or 50 other bearing apple trees which are scattered about the farm. He is thoroughly convinced as to the value of nitrate of soda to bring back to productivity neglected trees which are growing in sod and which are usually suffering from nitrogen starvation.

Orchard of Mr. A. B. Smith, of Clintonville

Among the 49 demonstration orchards supervised in 1923 there were six young orchards not yet in bearing. The owners of several of these have grown intercrops between the rows to help pay the cost of operation. Such a one is that of Mr. A. B. Smith of Clintonville. This young orchard of 10 acres has just completed its third season's growth. Besides cultivation, the trees each received about four ounces of nitrate of soda this year. The orchard is an excellent one for its age.

Mr. Smith's expenses for 1923 were about $200.00. Intercrops of squash and pumpkin were grown which sold for a total of $1162.58. This leaves him an income of over $950.00 from the 10 acres on which the young orchard is planted. Besides this income a growth of from 15 to 30 inches has been obtained on the young trees.

Demonstration Orchard Results

Table 1 which follows shows the yields, returns, etc., from 14 of the bearing demonstration orchards on which reports were received on or before December 18. The average net return above operating costs is $282.97 per acre as shown.

TABLE NO. I

Demonstration Orchard Results in Connecticut Reduced to Acre Basis, 1923

Grower	Number of Trees in Plot	Number of Trees per Acre	Age	Yield in Bushels	Expenses	Gross Returns	Net Returns	Number of sprays
Roth	48	48	49	800	$482.25	$1115.00	$643.25	8
Hurlbut	272	40	35	339	....	197.50	....	4
Johnson	48	48	26	123	47.58	163.25	115.67	6
Hawley	90	30	28	225	70.53	268.00	197.47	3
Kellogg	50	48	30	...	69.55	327.00	257.45	5
Beers	300	60	25	480	....	605.00	....	5
Humphrey	102	35	26	375	122.83	384.40	261.57	4
Cowles	80	35	12	...	63.10	191.50	128.40	6
Smith, E. E.	45	35	70	156	98.00	216.00	118.00	4
Clark	49	40	35	625	192.91	699.08	506.17	6
Lockwood	10	35	25	416	113.15	497.87	364.72	5
Larkham	43	35	60	400	158.50	408.50	249.75	7
Brewster	110	55	13	520	75.00	500.00	425.00	5
May	470	48	14-30	360	41.76	170.00	128.24	8
Average results ...	...	..	....	402	....	....	$282.97	.

Vegetable Gardening Teaching in Agricultural Colleges

By H. W. SCHNECK, *Cornell University, Ithaca, N. Y.*

THE Federal Bureau of Census figures indicate $14,755,364,-894.00 as the value of all farm crops raised in the United States in 1919, and $1,302,199,688.00 as the value of vegetables including potatoes. In other words, nine per cent of the value of all crops grown in the United States is represented by the value of vegetables. The census report also shows that nearly 79 per cent of the farms of the United States had farm gardens in 1919. In addition, hundreds of thousands of people in cities and towns grow vegetables for home use in backyard gardens, the value of which is not included in the census figures. The value of vegetables is greater than the value of all other horticultural crops. No other phase of agriculture interests so many people as does vegetable gardening.

One would naturally expect that a phase of agriculture of such importance, and in which so many people are interested, would occupy a very important place in a teaching program of our agricultural colleges. To secure information on this and other points a question sheet was addressed to all the agricultural colleges in the United States. Replies were received from all of these institutions. Only one institution does not offer any vegetable gardening courses. The number and kinds of courses offered by different colleges are given in Table 1.

TABLE I

Courses in Vegetable Gardening for Regular Four Year Students Offered by Agricultural Colleges in the United States

Courses	Number of Colleges
None reported	1
One	15
Two	14
Three	4
Four	4
Five	7
Over five	3
Total	48
General or elementary vegetable gardening	47
Advanced or commercial vegetable gardening	32
Vegetable forcing	18
Systematic vegetable gardening	12
Tuber crops	3
Vegetable seed production	2
Horticultural products	1
Vegetable marketing	1
Truck farm management	1
Practical laboratory courses	1
Total number of courses	118

In addition to these courses 21 institutions offer special two-year courses, short winter courses, or summer courses in vegetable gardening.

At Cornell, three sets of courses in vegetable gardening are offered by means of which it is aimed to meet the needs of all classes of students. One set is for summer school students, lasting six weeks, another for winter course students, lasting 12 weeks, and a third set for regular four-year students. Three vegetable gardening courses are offered in the summer school, an elementary course for students who have had no training or experience in vegetable gardening, an advanced course, and a course in systematic vegetable crops. The summer school courses are especially designed and planned to meet the needs of school teachers, although college students in Cornell or other universities who wish to make some scholastic use of their long vacation also take these courses. Summer school students are advised to accompany courses in vegetable gardening with courses in botany and soils, if such courses have not been taken previously.

In the winter, or short course term, two courses are offered which are intended primarily for persons engaged in farming, or who expect to take up farming. One course is elementary in nature for students engaged in, or interested in, general farming or other phases of agriculture, but who desire some knowledge of the principles of vegetable gardening. The other course is designed only for those who plan to make vegetable gardening their life work. Students are required to accompany this course with courses in soils, agricultural chemistry, entomology and plant pathology. Con-

siderable elementary botany is given in connection with the course in plant pathology.

For the regular four-year students, five courses are offered: principles of vegetable gardening, advanced vegetable gardening, vegetable forcing, systematic vegetable crops and a course in special crops in which the Irish potato is the principle crop considered. The course in principles of vegetable gardening, which is prerequisite to all other courses except the special crops course, is intended for the student in general agriculture who desires a brief course concerning the subject, and is an introductory course for the student who wishes to specialize in commercial vegetable gardening. This course is complete in itself rather than merely an introduction to other courses, because it is the only course in vegetable gardening taken by students in general agriculture.

Vegetable gardening teachers, in common with teachers of other agricultural college subjects, present their courses by dividing the work into three parts—first, by means of text-books and outside reading in books and bulletins; second, by lectures and recitations, and third, by laboratory work.

All except three of the 47 institutions offering an elementary course in vegetable gardening, require text books. Table 2 indicates the number of colleges using various texts. There is some duplication in these figures, some institutions using more than one text.

TABLE II

Text Books used for General Courses in Vegetable Gardening

Title and author of book	Number of Colleges
Vegetable Gardening, R. L. Watts	14
Garden Farming, L. C. Corbett	13
Productive Vegetable Growing, J. W. Lloyd	12
Principles of Vegetable Gardening, L. H. Bailey	7
Vegetable Growing, J. G. Boyle	1
Title not given	4

Outside reading assignments should give the instructor the foundation on which to base his lectures and recitations and should, therefore, be made in advance of, rather than after, the class period on the particular subject. The lecture and recitation should supplement the text book and other outside reading, and should not be designed merely to present information and facts which should be secured from outside reading, but rather as a means of clarifying outside reading material and of giving the students the proper attitude to the work of the course. Students should not only learn facts, but should be so trained as to use the facts to solve practical problems in vegetable gardening. The lecture period offers opportunity for the instructor to give illustrations from practical experience of the utilization of facts learned to the solution of practical gardening problems and of the application of principles learned to practical gardening operations. In this way the outside reading should be made clearer and should mean much more to the student, and should tend to make him much more interested in the work of the course.

Our students are required to hand in written reports on reading assignments outside the text, because we feel that by preparing reports they learn a good deal more about the subject than would be the case if they merely read the articles. Later in the course students are assigned topics on which they are to prepare papers. They are responsible for finding their own material for these papers, and must include a bibliography. This develops in the student an ability to rely upon himself and teaches him how and where to get information when he needs it.

Of the 47 institutions above referred to, only four require courses in fundamental sciences as prerequisite to their first course in vegetable gardening, and very few require them for advanced courses. Prior to taking courses in vegetable gardening at Cornell, four year students are required to get a broad foundation in fundamental sciences. We feel that if these courses in fundamental sciences are not required of our students in vegetable gardening, we will find ourselves teaching agricultural chemistry, botany, and soils, instead of the use of these subjects in the solution of vegetable gardening problems, or as I am afraid is too often the case, we will be teaching the mere art or practice of vegetable gardening, which most of us will agree is not the main function of vegetable gardening courses in an agricultural college. We feel that the function of an agricultural college course in vegetable gardening is to train students in the principles of vegetable gardening and to develop the ability of the student to appreciate and to solve the problems of the vegetable gardener. To accomplish this all experimental evidence available is brought to bear on the subject. This evidence comes from all fields of science which have anything to contribute to vegetable gardening problems.

Instead of basing our lectures and recitations upon only correct methods of growing and handling vegetables, we should have our students learn what happens and why when incorrect methods are used, giving fundamental scientific principles involved. Every practice and method discussed should be as far as possible, based upon a scientific principle. In this way, we get the student to understand why certain practices are followed. The student should not only learn how to harden off early vegetable plants before they go to the field, but he should also learn why this is important, what changes take place within the plants and how unhardened plants are affected by different conditions in the field and why. He should learn why it is important to artificially pollinate tomatoes in the greenhouse and why red spiders cannot be controlled by fumigation. If our lectures and recitations are not handled in this way, they will not be of university or college grade, but rather of trade school character. Our aim should be to give students something more than they can get in practical vegetable gardening operations, and that is an understanding of the principles involved and reasons for certain practices in vegetable production and marketing. With such teaching a knowledge of proper methods is learned although skill in these methods is not one of our aims. We feel that skill can be acquired only by practice, sufficient of which cannot be

given at an agricultural college because of lack of time and of proper environment.

The laboratory exercises are valuable as a means of teaching students the principles involved in the solution of vegetable gardening problems which is the fundamental purpose of our teaching. If a student learns the principles he can apply them to any phase of vegetable gardening work he may enter after graduation. Our students are held responsible for their plantings except for ventilation, heating and watering in greenhouses. All plantings are conducted in the form of test, or experimental exercises. This enables us to teach fundamentals and make the student think of the relation to gardening practice. The students receive for each exercise a typewritten direction sheet on which detailed directions are given also indicating observations to be made and data to record. They plant their crops and grow them continuously throughout the course. This tends to maintain their interest much more than if they handle plants grown by others. Conclusions to each exercise are written as a report of the laboratory work. Instead of merely showing students how to make a hotbed, hotbeds of different depths are used in which manure is placed and packed or firmed in different ways. The students make temperature readings in these different hotbeds from day to day and draw conclusions as to the practical management of hotbeds and give reasons for different temperature reactions which involve a knowledge of chemistry and bacteriology. By means of such simple experiments the student's interest is stimulated. He is eager to learn what will happen and then to learn why. He profits by doing things the wrong way by constantly having the question before him with each exercise—what is the right way and why. Sometimes the importance of proper methods can be more forcibly impressed by contrasts than in any other way. The important thing the student gets out of such laboratory exercises is not merely knowledge of facts, but the ability to utilize facts in the solution of problems in vegetable production and marketing. Much of our college teaching has been of the memory type, simply passing out information and facts to the student which he memorizes, and if he is a good parrot and can repeat what he reads and what the instructor says, we give him a high grade and consider him a good student. After such a student leaves college he often makes a failure, simply because success does not depend on his ability to memorize what he hears and reads, but rather on his ability to understand and to utilize facts in the solution of problems. It is this that we try to develop in our students taking vegetable gardening, an understanding of the principles underlying vegetable gardening and an ability to utilize these principles in the solution of problems in vegetable production and marketing. This requires considerable mental exertion beyond memorization and tends to train and develop men so that they may become leaders in vegetable gardening, regardless of what particular phase of vegetable work they may go into, whether teaching, research, extension, or into vegetable production and marketing.

Vegetable gardening has made immense forward strides in

our colleges during the past decade as far as number and organization of courses are concerned, and yet we do not find many students interested in the subject. The average registration in the elementary course in institutions where it is not a required course, is only 17 students, and in only two colleges is it over 20. In institutions offering more than one course, the average registration in the advanced courses, all of which are elective, is six students. The question naturally arises, what is the reason for this low registration and lack of interest in this subject on the part of the students.

This question was asked of vegetable gardening teachers in different colleges, and varying replies were received. The answers given by most of these men can be summed up in one sentence—"Perfect the teaching of the subject." The question is, how can this be done. It is my feeling that the first and most important thing needed to improve our teaching is more fundamental research in vegetable gardening. This will furnish us a basis for more scientific teaching. If we had the same amount and fundamental type of research that pomology has today, vegetable gardening would probably attract more students. Although there exists a great need for more research work in vegetable gardening, vegetable gardening teachers have not utilized to the fullest extent what horticultural truth has been discovered.

This probably is due to the fact that the material is scattered and found mostly in connection with other problems than truck crops directly. But it is the teacher's job to find and to utilize this material. This lack of fundamental material on which to base vegetable gardening teaching makes it a very difficult subject to teach. Necessarily considerable material that the instructor utilizes and most of our text books in vegetable gardening simply consist of empirical information.

Another way in which our teaching can be improved is by securing more teachers who have had not only practical gardening experience, but who have been throughly trained in the fundamental sciences underlying vegetable gardening, and who can devote all of their time to the subject instead of the major part of it to pomology or other fields. In only 15 of the 47 institutions mentioned does vegetable gardening occupy all of even one man's time. In most of the other 32 institutions the subject is given as a side issue by pomologists. Where the teacher does devote all of his time to this subject, he is usually expected to devote considerable of it to extension and research in vegetable gardening in addition to teaching. In order to teach most effectively it has been my feeling that a teacher should devote most of his time to teaching, especially in a study like vegetable gardening where the subject is just beginning to be developed in a scientific way and where the material is so disorganized and scattered. A great deal of his time should be taken up in searching and researching through literature for the scientific facts on which to base his teaching.

The teacher should also devote much attention and time in studying the proper methods of teaching his subject. It is necessary for him to have a thorough knowledge of his subject and of the fundamental sciences related to it. He should also have train-

ing in psychology and teaching methods. This latter requirement is not given important consideration by those employing vegetable gardening teachers. It has been said "teachers are born, not made." This undoubtedly is true to a large extent, but a teacher's methods of teaching can be greatly improved by a thorough training in the underlying principles of teaching and an ability to apply these principles to the teaching of vegetable gardening. A thorough knowledge of all the sciences underlying vegetable gardening practices is of little value in teaching unless the teacher has the knowledge and skill in the proper methods of using this material in teaching students vegetable gardening.

A fourth need for perfecting our teaching is more equipment in the form of greenhouses, hotbeds, cold frames, and land. Vegetable gardening classes do most of their work with live plants, which means that not only are buildings containing class and laboratory rooms required, but in addition expensive greenhouses, hotbeds and cold frames and considerable outdoor land, tools, implements, seed and very large amounts of fertilizers with which to grow these plants. This necessarily makes the teaching of vegetable gardening very expensive as compared to many other phases of agriculture, which has discouraged agricultural college authorities from developing the subject. Still, when we consider the economic importance of vegetable gardening and the large part of the population directly interested in the subject, in most states the expense involved is fully justified.

One of the most logical ways of securing the needed teaching facilities is by developing and expanding our extension work in vegetable gardening, wherever possible pointing out the importance of the vegetable gardening industry and advertising the importance of vegetables in the diet. Our extension men in vegetable gardening can be of inestimable help to us by arousing interest among commercial vegetable growers in the work of the college so that they will demand proper financial support for both teaching and experimental work. This will also bring vegetable gardening students from vegetable growing sections to our colleges.

A fifth way in which our teaching may be perfected and attract more students is by devoting more time to inspection of commercial market garden and truck farms, and by having students analyze causes of success and failure of different growers. Study should be made of not only the production but also the marketing as a factor for success or failure. Many students think gardening work is drudgery. Some inspection trips will do more than any other thing to discourage this idea.

All of these things will help to create more interest among students in vegetable gardening, but the one thing that underlies all and that is needed more than anything else to perfect our teaching as well as to improve our vegetable gardening extension work, is more experiment station work of a fundamental, or research, character. Not until we secure this can we hope to raise the subject of vegetable gardening to the high place in the minds of students in our agricultural colleges that its importance deserves.

Summer Work in Pomology

By F. W. ALLEN, *University Farm, Davis, Calif.*

THE value of summer practice work in the teaching of agriculture has been recognized for a number of years, but few agricultural colleges have been so situated that such courses could be offered. For some 10 years the University of California has not only offered a six weeks practice and travel course in each major division of the College of Agriculture, but has required it or its equivalent as a prerequisite to graduation. Where the extra expense in connection with such a course would work a financial hardship on the student, arrangements are made whereby he may work on some approved ranch during the summer, receiving compensation for his labor. In this case, however, the approval of the instructor must be secured in advance of the opening of the course. Work on approved ranches will be considered as fulfilling this graduation requirement, providing the student submits a satisfactory report of the work performed and is able to satisfy the instructor that he has really secured a comprehensive knowledge of the farm operations in that particular section. Such work, however, does not count for credit units toward graduation. At least junior standing is required before one is permitted to register for a summer practice course. Preferably it should be taken between the junior and senior years, after the student has had his general fundamental training and when most desirous of securing as intimate a knowledge as possible with his chosen line of work.

Of the various agricultural divisions, the Division of Pomology at the University Farm, is at the present time perhaps the best equipped of any for giving this type of work, and the class of the past season with an enrollment of 25, represented widely different sections of the United States as well as Egypt, South America and South Africa.

The first and perhaps primary feature of this course is to give the student practical work in fruit handling. Owing to the fact that 100 acres of orchard is maintained and the mild winters make it possible to give a large amount of laboratory work throughout the college year, the summer course is confined almost entirely to the commercial rather than the productive phases of pomology. Supplementing the orchards a large, well arranged and completely equipped packing house, conveniently located, provides excellent facilities for giving instruction in the packing of various kinds of fresh fruit. Unlike most other states where the apple is the chief fruit crop, California has numerous fruits of commercial importance ripening during the summer months. Cherries, plums, apricots, prunes, peaches and pears furnish a variety of material and three to four weeks of the six are spent in harvesting, packing and drying these fruits.

All fruit intended for eastern shipment is packed in standard containers and is shipped through the California Fruit Exchange,

a large cooperative marketing organization, to such markets as Chicago, Baltimore, and New York. The fruit is handled in a strictly commercial manner. The packers must, therefore, give special attention to proper maturity and grading, as each lot of fruit packed must meet the requirements of the California Fresh Fruit and Vegetable Act, before it will be accepted for shipment. As in commercial packing houses, each student packer is given a number and this number is placed on each box or crate of fruit which he packs. With inexperienced packers it is only natural that for the first few days numerous packages will be "condemned" in the packing house and returned to the packer for closer grading as to maturity, size or other defects. No one likes to pack the same box of fruit twice, hence this system of strict inspection impresses itself upon those doing the work and good packers are developed in a comparatively short time. Emphasis is placed upon proper methods rather than speed, as the latter can be developed only by continued practice.

After several days packing any one fruit and at intervals during the packing season, day or half-day trips are made to adjacent fruit sections to observe the methods of packing and handling in commercial packing houses. The practices seen in these naturally vary quite widely, but with some previous experience in the work the average student is quickly able to distinguish between careless handling and poor packs in contrast with the methods of the grower who is interested in turning out a high grade product.

Not only are packing houses visited on these trips, but also shipping sheds, where the fruit passes under the eye of the state inspectors. Here is explained and demonstrated the method of examination which each lot of fruit must pass. At these points opportunity is also given to see the loading of the fruit into the refrigerator cars. The arrangement of the packages in the car, method of bracing, icing, making out the car manifest and the construction of the car itself are interesting points which are observed and studied. For the first time most of the men are impressed by the fact that after a box of fruit is produced and packed in California it still has a long way to travel before the final purchaser carries home some of the specimens in a paper sack; also if it is to reach the consumer in good condition after its long ride across the continent it must be handled both carefully and expeditiously. Proper stage of maturity before harvesting, better methods of handling and shipping in order that perishable fruit such as cherries, apricots, peaches and pears, will arrive on the eastern markets in good condition, are questions of vital importance to western growers.

But with the majority of California's deciduous fruits, shipping fresh is in reality secondary to drying and canning. Practice in dry yard work is, therefore, not overlooked. Each different operation, such as cutting, sulphuring and the lye dipping of fruits, as well as placing the trays in the field and stacking, is carried on by those enrolled in the course. In visiting different fruit sections dehydrator operations are also closely observed.

While canning is primarily a commercial operation foreign to the grower, yet cannery requirements as to variety, grade, size and maturity of fruit, are matters of vital concern to the producer. Lack of facilities prevent practical cannery work being given as a part of this course, but visits are made each year to large canneries in Sacramento, 14 miles distant, and also to a number of others in different sections of the state. Not only has the class always been accorded the privilege of seeing through these canneries and having each process explained, but from the managers have obtained much valuable information as to the kind of fruit in greatest demand for canning, and how the grower may hope to obtain better prices and work in closer cooperation with this valuable industry.

The second purpose of this course is to give the students an opportunity to learn something of their chosen subject directly from the leading growers, shippers and commission merchants. Personal contact with such men in their orchards, or at their place of business, is an opportunity which students rarely enjoy, and the value of such contact can scarcely be estimated. In the visiting of orchards, a definite itinerary is usually made out by the local county farm advisor each day, and arrangements are made in advance to meet the grower personally and have him explain his methods. Each stop made is planned to illustrate some successful practice, a piece of new machinery or equipment, or some improved method in connection with handling of the crop. The growers although busy at this season picking and packing their fruit, gladly give of their time and experience. In one instance after going through the orchard, the class spent nearly an hour under the shade of the trees listening to a most interesting talk on the development of fruit growing in the Sierra foothill section, and in receiving much valuable advice from one vitally interested in the success of young men contemplating the planting, or purchasing, of orchards. The impression made upon the members of the class will probably remain long after they have forgotten many things learned in the class room.

Managers of cooperative canneries and shipping associations as well as private shippers and commission merchants, have been willing to give much information in connection with the marketing of fruit. The course is scarcely considered complete without an early morning visit to the San Francisco wholesale fruit market. After observing the kinds, grades, and quality of fruit offered for sale, and later having local marketing problems discussed by one of the leading commission men—incidentally a University graduate—the students are impressed with the fact that successful marketing is a tremendous task. They cannot but also be impressed with the fact that if each fruit grower could see his fruit when exposed for sale in competition with that of other growers, he would realize perhaps after all that he was receiving a fair price, though not necessarily a profitable one, for his product.

Aside from the practical experience in fruit handling and meeting with successful growers and shippers, the travel feature of this course enables one to see and compare the different fruit sections of the state. Western fruit sections are quite well defined,

one district specializing in early shipping plums and apricots, another in canning peaches, a third in the production of prunes or raisins, and still others in apples, almonds, olives, oranges, etc. These sections may be situated near the coast, in the great Sacramento-San Joaquin Valleys, or in the Sierra Nevada foothills. The altitudes vary from only a little above sea-level to 3000 feet. Climatic conditions range from sections almost frostless to those having regular winter temperatures common to most states. Soil conditions and general topography also vary widely. Good soil, sand, gravel, clay and hardpan, may all occur in close proximity. Land values range from $150.00 to $2,000.00 per acre depending upon soil type and location. Fruit is grown in many sections without irrigation, in others it is absolutely essential. Certain disease and insect pests, very deterimental in one region may be almost unknown in another. Seeing these localities and at the same time having presented the facts regarding each, is of valuable assistance in connection with the choosing of a location, and after three years of college work it serves to bring the student into close contact with the industry in which he plans to engage.

The question of satisfactory transportation for 25 men has been one of the difficult problems in connection with this work. City markets and canneries might be satisfactorily reached by train, but this is not possible in visiting orchards. Automobiles are thus used entirely and with all main highways paved, a distance of 100 miles or more may easily be covered in a day.

Previous to last year the Division of Pomology endeavored to make arrangements for a bus or enough cars to furnish transportation for each man. Such an arrangement however entailed a great deal of responsibility upon the instructor giving the course and in other ways did not prove entirely successful. For the past two years, each student has been made entirely responsible for his own transportation and the plan has been most satisfactory. Before the closing of school in May a registration list is made up of those intending to take the summer work. Among those registering there have been a sufficient number owning or having the use of cars so that by taking three or four other men in with them every one can be accommodated. The cost of operating a small machine has been estimated on a basis of eight cents a mile and each occupant of a car pays his share of the transportation expense. With baggage, four individuals make an ideal load for a five passenger car and at a cost of eight cents per mile the individual cost is two cents—very cheap transportation. In one instance four students purchased a second hand car at the beginning of the course and after finishing their trip, totaling approximately 2000 miles, sold it for enough profit to pay for the cost of operation.

Lodging costs are of minor consequence since camping out has proven more popular than staying at hotels. Since summer rains are practically unknown, the only camping equipment necessary is a roll of blankets. "Lodging" is usually easily found in municipal camp grounds, or in a nearby alfalfa field. Instructors are of course not responsible for the students' conduct between the time the group is dismissed in the late afternoon until eight o'clock

the following morning, but this freedom is in reality a distinct advantage as the idea of keeping them all in one group at a hotel has proven to be the worst plan possible. Meals are an item of expense which cannot be avoided. However, the cost of board can be regulated according to one's circumstances and in most instances will not greatly exceed that paid during a similar period while in regular school session.

One week after completing the course each student is required to submit a notebook covering the entire work of the six weeks. These notebooks frequently contain as many as 150 typewritten pages, together with numerous kodak views of different operations and places visited. The students are unanimous in their opinion that the course is the most interesting and helpful of any offered in the curriculum.

Second Year's Experience in Supervised Summer Practicum for Horticulture Students

By F. N. FAGAN, *Pennsylvania State College, State College, Pa.*

AT the 1922 meeting of our Society, Dr. S. W. Fletcher presented a paper on the Summer Practicum as conducted at the Pennsylvania State College. Our second summer with the supervised practicum, however, brought forth a few additional points of interest. We thought likely it would be well to let the Society benefit by our experience if applicable to other colleges, especially since the department had received several letters asking for information, and were paid a visit during the summer by the dean and department head of another land grant college.

We were unable to establish a camp for the students as we had hoped to do after the experience of 1922. It was necessary to house the students in the town. The practice in 1922 was to pay the student a wage to cover the cost of room and board. This was discontinued in 1923. We deem this necessary, because in 1922 the tendency of those in charge of the practicum, was to receive enough labor from the students to justify this expense, and this was found difficult to do especially since our aim was to vary the work enough each day to give the student some work in the many and varied operations connected with conducting a fruit, vegetable, or flower business. The tendency was to slight the academic side of the practicum when the department was paying out money each week to the student.

The students of the 1923 section did not look with favor on this change, as it meant six weeks of expense, and spoiled the summer vacation period for the earning of money to help pay expenses in the school year of 1923-24. This attitude had to be overcome, and it was up to the instruction staff to so arrange the practicum work with enough academic instructions to off-set this attitude.

This was accomplished by outlining the practicum with a one hour class discussion and accompanying reference readings. This class was held the first hour each morning. In general the discussion centered around the work in the field to be pursued the rest of the day. This paved the way for the labor part of the course, and the student was on the alert for points of interest during the hours of field work, resulting in the asking of many intelligent questions, which would not have come forth otherwise. The labor ceased to be labor to a large extent. The students' enthusiasm continued throughout the six weeks, and we feel that it was better at the end of the period than at the beginning.

With five weeks at our command, we were able to take up in detail about 25 different phases of horticultural operations. To broaden the viewpoint, we even brought in the instructors in charge of "feeds and feeding," and the college veterinarian to give the students some work in the care of work stock. This proved to be of great interest, as the average horticultural student at our college receives but little instruction along this line in his regular course. It is necessary, we believe, not to confine the work to any one line of horticulture so closely as to eliminate the side line operations that will confront the manager of the average horticultural enterprise.

We also feel that many students who have never worked in the field, need to appreciate what this future labor may be like, while working day after day at the same operation. This was forcibly brought to the writer's attention this past summer, when after having the students pick raspberries for a day, one of them made this remark: "Well after today's experience, I have much more respect for the berry picker than I ever had before." He was in better shape to manage a berry-picking crew after such an experience, and I am not so sure but that teachers of psychology would benefit themselves by a little experience in managing a berry-picking crew.

For a few days we found it necessary to use the students as laborers. This was the case in our peach and apple thinning work, and also to complete the tree bracing before the crop became too heavy. When this was necessary, the wage of our regular laborers was paid the students. This helped to maintain their good will.

One important benefit resulting from this intensive practicum is the intimate knowledge the instructor is able to acquire in respect to each student. The instructor is in much better shape to pass upon the qualities of the student after a summer practicum of this kind. If he does not become thoroughly acquainted with the student, it is probably his own fault.

We feel that the summer practicum is a success from the academic viewpoint, which probably was the hardest viewpoint to satisfy in our own minds. We feel that such a practicum should be so conducted as to warrant its place in a college or university catalog. From the expression of the students taking the work in 1923, we feel the effort is justified and worth while.

We closed the practicum with a week's inspection trip through orchards, gardens, greenhouses, nurseries and parks in Pennsyl-

vania and New York, which brought forth many interesting details of horticulture under its varied conditions, and which call for different handling under the different conditions. All of this broadens the students, and fits them for a better understanding of their college studies in following years.

Orchard Judging—A New Feature in Pomology Teaching

By W. P. DURUZ, *University of California, Davis, Calif.*

ORCHARD judging has recently been introduced by the Division of Pomology of the University of California. The idea was suggested by Dr. W. L. Howard, Head of the Division. The suggestion was received with enthusiasm by the staff and students of pomology and soon developed into an activity of valuable promise.

The primary aim of orchard judging is to train students to know the essentials of a *good orchard.* It is the practical application of the principles and practices as taught by lectures and laboratory work. The relative importance of soil, climate, location, pruning, spraying, irrigation, pollination, thinning, etc., is brought out and emphasized in the various orchards that are judged.

The following score card was drafted by the writer for the purpose of judging orchards:

SCORE CARD FOR ORCHARD JUDGING

Counts

I. Location, Site and Soil 50

A. *Location* 15

1. Climate—temperature, rainfall, sunshine, frosts, fog, limit of growing season, etc.
2. Transportation facilities,—Roads, rail and water.
3. Area devoted to fruit growing in locality.
4. Desirability of the place for a home.

B. *Site* 15

1. *Aspect or Slope*
   a. With reference to sun.
      1. Ripening and coloring of fruits.
      2. Frost injury on eastern slopes.
      3. Sunscald.
   b. With reference to winds.
      1. Does land slope towards prevailing winds?
   c. With reference to application of irrigation water.
      1. Can water be efficiently and cheaply applied?
2. *Atmospheric Drainage*
   a. Will cold air drain off? Is there slope enough?
   b. Does cold air come down from slopes above; is orchard set at the foot of a long slope?

c. Is there any obstruction at the bottom of the orchard to hold cold air?

3. *Windbreaks*
   a. Nearby or distant?
   b. Character of windbreaks?
   c. Position of windbreak for effectiveness against prevailing winds.

C. *Soil* 20

1. *Surface Soil*
   a. Ease of working.
   b. Sour or alkali.
   c. Humus.
   d. Depth.
   e. Plowsole or hardpan.
2. *Subsoil*
   a. Ease of penetration by roots.
   b. Depth.
3. *Water Drainage*
   a. Surface drainage.
      1. Good? Does water stand?
      2. Too much?
         a. Washing, loss of soil and fertility.
         b. Loss of water.
   b. Sub-drainage.
      1. Enough? Is soil soggy?
      2. Too much? Is soil too dry?
      3. Seepage water in irrigated sections.
   c. Sub-irrigation.
      1. Present?

II. Condition of Trees 35
(Use either A or B below)

A. *Non-bearing trees.*

1. Size for the age and kind of tree 5
   a. Caliper of trunk 4 inches from ground.
   b. Height.
   c. Influence of pruning on size.
   d. Uniformity of stand.

Counts

2. *Form* 5
   a. Height of head.
   b. Scaffold branches.
      1. Number.
      2. Spacing.
      3. Angle of branching.
   c. Secondary scaffold branches.
      1. Number.
      2. Height.
   d. Watersprouts or suckers present?

3. *Vigor* 10
   a. Terminal growth.
   b. Hardness.
   c. Bud development.
4. *Health* 15
   a. Disease, insect or physiological injury.
   b. Sunburn, cracks, cuts, etc.

B. *Bearing Trees.*
1. *Size for the age and kind of tree* 2
   a. Height.
   b. Spread.
   c. Balanced wood throughout tree.
   d. Influence of type of pruning on above.
2. *Fruitfulness* 10
   a. Yield and quality of recent years.
   b. Condition of fruiting wood; prospects of crop.
   c. Distribution of fruiting wood.
   d. Quantity and development of fruit buds for next season.
   e. Variety—good commercial sort.
3. *Vigor* 8
   a. Length growth past season.
   b. Condition of new wood.
   c. Premature dropping of leaves.
4. *Health* 15
   a. Disease, insect or physiological injury.
   b. Sunburn, broken branches, cracks, cuts, etc.

III. Condition of Orchard in General 15
A. *Care of Soil* 8
   1. Cultural treatments.
   2. Planting distance.
   3. Irrigation.
   4. Cover crops.
B. *Care of Trees* 7
   1. Method of pruning.
   2. Bracing or propping.
   3. Tree surgery and repair.
   4. Whitewashing.
   5. System of spraying.
   6. Pest eradication and control.
   7. Orchard sanitation.
      a. Burning brush, weeds, rubbish, etc.

Total Counts 100

It will be noted from the above score card that the principal items involved in judging an orchard are location, condition of trees, and the general condition of the orchard. The orchard is

judged in its present condition the same as is the case in judging horses, sheep, etc.,—*not* as to its economic value, that is, whether it is a "good buy," or whether or not it can be developed into a good orchard in the future.

With the score card as a basis with which to start the work, we began by devoting some of the regular laboratory periods to scoring. The meaning and significance of the various items outlined in the score card, were explained by the instructor. Then the students were required to score several orchards. A critique was held at the end of each period in order to make the scoring standard. Soon we were able to dispense with the actual scoring and to judge orchards by comparison only, the same as is the custom in livestock judging. With the main factors on the score card in mind, students would go over an orchard, take soil borings and make notes regarding points observed, and then when all were ready the group moved to the next orchard. When all the orchards in the class (medium aged peach orchards, for example), which the instructor had previously selected, were judged, students were required to hand in their placings and each student was then called upon to give oral reasons for his placing. Judging was then continued on the next class, (for example, old pear orchards).

A great deal of interest was aroused among the students and they requested that more time be given to judging. This was impossible during the regular hours and so was accomplished after school hours and on week-ends. The students gave voluntarily of their own time and arranged their own transportation, first using private automobiles and later renting a large bus for the trips.

At first short trips were made to the nearby fruit districts visiting and judging the leading commercial orchards. Incidentally, the students derived a great deal of benefit in seeing different methods of orcharding in the various districts that were visited.

Later in the spring, longer trips were urged by the students. To do this satisfactorily, we had to travel on Saturday and Sunday on two occasions. Farm advisors in the counties we wished to visit were requested to cooperate with us in planning our itinerary and in arranging with growers for the judging of their orchards. This they did most heartily and thus provided well-planned trips for us.

Early in the year the suggestion was made to Oregon Agricultural College, and to Chaffey Junior College at Ontario, California, that orchard judging be taken up by them with the hope of having teams representing their institutions and ours meet in an orchard judging contest. Our challenge was accepted by Chaffey Junior College and a team of freshmen and sophomores was selected to meet their team at Ontario.

Plans are now under way for inaugurating an annual intercollegiate orchard judging contest next year, to include teams from Oregon, Washington, Idaho, Utah, Colorado, New Mexico, Arizona and California.

It is our belief that orchard judging is far more valuable to the average student than apple judging, or any other fruit judging. From our experience, only a very small number of students utilize the training received in fruit judging, while a great many would

be benefited by orchard judging. Orchard judging trains students to know and appreciate good orchard management and, therefore, how to grow the best fruit. The production of a high yield of good fruit is of first concern to the average fruit grower.

Storage of Starch in the Pear and Apricot

By S. H. CAMERON, *University of California, Berkeley, Calif.*

IN view of the fact that little has been published with reference to movements of starch in bearing fruit trees, other than in the spurs, and because of the belief that lightly pruned trees begin the storage of reserve food earlier in the season and deplete this reserve later in the spring than do heavily pruned trees, it was thought that it might be well to investigate these points.* Microchemical tests were, therefore, made upon material collected from full bearing, eight year old trees of Bartlett pear and Royal apricot, growing in the University Farm orchard at Davis.

Some of the trees had been regularly pruned by merely thinning out the younger branches, always cutting back to the parent branch, or to a lateral. The others had been regularly pruned by removing each winter from two-thirds to three-fourths of the new growth. The former are referred to as "nonheaded," the latter as "headed" in the following discussion.

Growth up to six years of age, including non-bearing spurs in their first year of growth, was used in the investigation. Collections were made at intervals of two weeks from January to April and at intervals of one month throughout the remainder of the year.

As reported by previous investigators for forest trees, two minima and two maxima were found for starch in both the pear and apricot occurring at approximately the same time. The first minimum was in May and early June, the first maximum in October and early November. The second minimum occurred in the latter part of January and the early part of February, and was followed by a second maximum in the latter part of February. The second maximum was simultaneous with the blossoming of the apricot. The pear, however, did not blossom until about the third week in March, at which time no decrease in the starch content was observable except in the cambium region. After blossoming, there was a steady decrease in the amount of starch in the younger branches of the apricot, although the spurs were still heavily stored. The decrease came later in the pear and was much less rapid than in the apricot.

Nonheaded trees began the storage of starch earlier in the season than did the headed trees. The difference was more noticeable in the two and three year old branches than in the current

* Starch storage was investigated as one phase of a comparative study of growth of "nonheaded" and "headed" trees of pear and apricot. The investigation was suggested by Professor W. P. Tufts and carried out under his direction.

season's shoots and spurs. This may be accounted for by the presence of more young spurs on the older branches of nonheaded than on corresponding branches of headed trees. These spurs with their large leaf area and limited growth probably synthesized more than they could store and excess was deposited first in the adjacent branch. The apparent differences in the amount and rate of storage in the headed and nonheaded trees were not so great as might have been expected. The apricot, because of its more vigorous response to heavy pruning, showed the above differences to a greater extent than did the pear.

There was apparently little difference in the relative amount of stored starch in the younger portions of nonheaded and headed trees. However, the older portions of headed trees showed relatively less storage than corresponding portions of nonheaded trees.

The apricot stored the bulk of its starch in the medullary rays and bark and showed a decreasing amount of starch toward the center with increasing age of the branch. This last was not true of the pear which stored the bulk of its starch in the pith, medullary rays and wood parenchyma. Collections were not made frequently enough to determine definitely the order in which the several tissues were stored, but it appeared to be the following: for pear—medullary rays, wood parenchyma, pith and cortex; for apricot—medullary rays, wood parenchyma*, cortex, and pith in the order named. It decreased first from the phloem in both pear and apricot, followed in the pear by the cortex, wood parenchyma, medullary rays, and pith, and in the apricot by the pith, wood parenchyma, cortex and medullary rays. Throughout the growing season there appeared to be always some starch in the cortex, especially in that of the apricot. The order of disappearance in the pear is in accordance with Price's (1) findings for the apple except that he does not report storage in the bark, but rather intimates that there was no storage in that region. He found starch in the bark in the spring. Starch began to disappear in the spring from the nonheaded trees before it did from the headed trees. There was, however, only a partial disappearance, followed by an increase before the buds burst. After growth started, disappearance was again most rapid in the nonheaded trees. Field observations on the rate of growth of headed and nonheaded trees, indicated that such would be the case. The headed trees were slower to come into blossom and leaf than the nonheaded trees. Especially was this true of the pear which grows more slowly than the apricot.

With the beginning of growth activity in the spring, starch disappeared first from the terminal portion of shoots, then progressively downward into the older portions of the branch. This was clearly shown by the pear but not so well by the apricot where the disappearance seemed to be nearly simultaneous as far down as the branch was studied. More frequent collections would possibly have demonstrated the same progression as in the pear. Price (1) found the same condition in mature apple trees. He found starch

*Wood parenchyma was very limited in the apricot, being present chiefly around the tracheae of the early season's growth.

to disappear first from the one-year-old twigs, then later from the older portions of the branches.

So far as the writer is aware, aside from the work of Hooker (2) on apple spurs in Missouri and the observations of Price (1) on mature apple trees in Ohio, previous workers conducting similar investigations have used hardwood trees native to their respective districts, which for the most part lie between the winter isotherms of 30° and 40° F. or less. Sinnott (3), however, reports that he found similar transformations in the Gulf States and in New England. The foregoing observations indicate that starch transformations are essentially the same in fruit trees in a region lying between the winter isotherms of 40° and 50° F. as they are in other hardwood trees in regions of rather severe winter climate, and merely lend support to the belief expressed by previous investigators that factors other than low temperature must be operative.

Feeding Trees Independent of Root System

By J. H. Gourley, *Experiment Station, Wooster, Ohio*

LANTERN slides were shown of methods used in adding nitrogenous food materials to apple trees independent of their own root systems. Results of this work are not available and the object in reporting it at this time is to offer a suggestive method of work for those who are studying translocation of food materials through a tree.

One method was by syphoning the solution from a flask hung in the tree and connecting the syphoning tube with glass tubes inserted into the tree trunk at varying distances from the ground.

Another was by planting a one-year old nursery tree in a tub at the side of the tree to be treated. By inarching this whip into the body, or some branch of the tree, an additional root system is provided which can be used in "feeding" the original tree.

A third method used was by grafting a root into the body of a tree, so that the lower ends did not touch the ground by a couple of inches. Earth was mounded up against this root graft and a root system was provided that could be inserted into glass containers and supplied with any salt solution desired.

(1) Price, W. A., Starch in Apple Trees. Ohio Journ. Sci. 16:356-359. 1915.

(2) Hooker, H. D., Jr., Mo. Agr. Exp. Sta. Res. Bul. 40. 1920.

(3) Sinnott, E. W., Factors Determining the Character and Distribution of Food Reserves in Woody Plants. Bot. Gaz. 66:162-175. 1918.

Effect of Premature Harvest of Plums and Pears

By E. L. OVERHOLSER, *University of California, Berkeley, Calif.*

THE fact that plums and pears are, in certain sections, frequently picked for eastern shipment in a state of marked immaturity, or in too green a state of ripeness, is widely recognized by pomologists familar with the larger markets. The growers, in the past, however, have not understood the situation, and probably have not realized the ultimate effect of this practice upon the industry.

REASONS FOR PREMATURE PICKING

There have been perhaps three primary reasons why plums and pears have been picked too green: (1) The jobbers of the eastern markets have demanded green fruit, especially in the case of plums, even though the quality was not good, in order that they might have more time in which to sell and still suffer no losses from overripeness.

(2) The growers have felt it was necessary to pick their fruit green because of the opinion that otherwise it would not withstand transportation and handling upon the market.

(3) There has always been the desire to reach the early market and obtain the high prices sometimes received for the first lots of fruit shipped.

EFFECT OF DEGREE OF MATURITY UPON PLUMS

The data obtained during the past two seasons with fruit from Niles and Davis, California, emphasize the fact that the degree of maturity, which fruit has attained when picked, exerts a profound influence upon the keeping quality, the sugar content and the flavor developed.

The effect of the maturity at the time of harvest upon the factors just mentioned is shown in Table I, which gives data, selected from tests with 16 varieties, as being typical.

TABLE 1

Effect of Maturity at Time of Harvest upon Keeping Quality of Plums at 32°F. (1922)

VARIETY	Region where grown	1st, 2d, or 3d picking	Date picked	Condition of fruit upon entering storage	Per cent of sugar at time of picking	Days kept without storage	Optimum storage date	Condition of fruit at optimum storage date	Days marketed after removing optimum storage	Condition of failure in storage
President.....	Niles	1st	Aug. 12	Hard ripe, purplish	11	8	Sept. 20	Firm, quality fair	8	Flesh browning
President.....	Niles	2d	Aug. 19	Firm ripe, purplish	12	10	Sept. 25	Firm quality good	9	Flesh browning
President.....	Niles	3d	Aug. 28	Firm ripe, purplish	17	12	Sept 30	Firm, quality very good	7	Flesh browning
Satsuma.....	Niles	1st	July 20	Hard ripe, purplish	6½	12	Sept. 10	Firm ripe, quality fair	9	Flesh broken down
Satsuma.....	Niles	2d	July 31	Firm ripe, purplish	7	12	Sept. 10	Firm ripe, quality fair	9	Flesh broken down
Satsuma......	Niles	3d	Aug. 5	Firm ripe, reddish purple	10	9	Sept. 20	Firm ripe, quality good	7	Flesh broken down
Santa Rosa....	Niles	1st	July 12	Firm ripe, red	10	10	Aug 10	Firm ripe, quality good	10	Flesh browning
Santa Rosa....	Niles	2d	July 20	Firm ripe, red	12	10	Aug 10	Firm ripe, quality good	10	Overripe, very soft
Santa Rosa....	Niles	3d	July 22	Medium ripe, red	15	7	Aug 10	Ripe, quality very good	7	Overripe, flesh broken down
Wickson......	Davis	1st	July 18	Hard unripe, green	9	10	Aug. 21	Firm ripe, quality good	10	Flesh browning
Wickson......	Davis	2d	Aug. 1	Firm ripe, pale green	8½	10	Sept. 19	Medium ripe, quality good	8	Flesh browning
Wickson......	Davis	3d	Aug. 3	Firm ripe, yellowish	13½	9	Sept. 20	Med. ripe, quality very good	9	Flesh browning

This is further emphasized by a summary of the data for the 16 varieties: Abundance, America, Apple, Botan, Combination, French (Agen), Grand Duke, Italian, President, Santa Rosa, Satsuma, Sergeant, Sugar, Sultan, Wickson and Yellow Egg, as follows:

1. The average date of harvest for third picking was 17 days after the first picking. The third picking kept nearly as long as the first, and the period of marketability was not materially lessened.

2. The average sugar content of the first picking of 16 varieties was about 10 per cent as determined by sap density measurements with a Balling hydrometer, and the third picking 16 per cent. This appears to be an increase of about 40 per cent in the sugar content.

3. The flavor and quality attained by the plums of the first picking was "poor to fair." The flavor and quality attained by the third picking was "very good to excellent."

4. The average increase in size of the plums between the first and third picking as determined by volumetric displacements and measurements was about 45 per cent.

Effect of Degree of Maturity upon Pears

Cooper (1) claimed that Bartletts were generally picked too green and that such pears tended to rot at the core. He (2) suggested that the fruit should be harvested when the seeds turned brown.

Stubenrauch and Ramsey (4) found that first pickings of Bartlett pears made when the fruit was still relatively immature deteriorated more rapidly than pickings made late. They found by leaving the fruit on the trees about two weeks longer, that the season could be extended for from six to seven weeks. The suggestion was made that the number of pickings should be sufficient to allow all the fruit to mature on the tree.

Magness (3) concluded that at the higher temperatures (70°F), early pickings kept longer than later pickings. At 40°F. storage the early picked fruits scalded and became brown rather than ripening to good condition. The later pickings, however, ripened to full yellow and prime condition with almost no scald. Late picked fruit tended to become yellow more quickly than early picked fruit, but remained firm in a prime eating condition for a longer period of time.

An experiment to determine the effect of degree of ripeness at the time of harvest upon the keeping quality in cold storage was conducted.

The Hardy, Bosc, and Comice from the Santa Clara Valley, were employed, and stored at both 32°F., and 36°F. The average picking dates for the four seasons 1919-20, to 1922-23 inclusive, of the three varieties as influenced by the stage of development when picked, are summarized in Table II. The height of the commercial harvesting period conformed to the second picking of each variety.

TABLE NO. II

The Effect of Maturity at Time of Harvest Upon Keeping and Eating Quality in Cold Storage of Pears

Variety	Average date picked 1919-23	Days marketed	Optimum Storage Date			Maximum Storage Date			Temp. of storage	Cause of failure in storage	Quality
			Date	Days	Days marketed	Date	Days	Days marketed			
Bosc	Aug. 22	15	Nov. 23	93	14	Feb. 1	162	7	32°F	Wilting and scald	Fair
Bosc	Sept. 1	18	Dec. 22	112	15	Feb. 10	162	8	32°F	Wilting and scald	Good
Bosc	Sept. 10	21	Jan. 10	122	17	Mar. 1	172	10	32°F	Wilting and breakdown	Very good
Bosc	Sept. 20	15	Nov. 25	66	9	Feb. 1	134	6	32°F	Breakdown	Excel
Bosc	Aug. 22	15	Dec. 1	101	10	Jan. 20	151	7	36°F	Scald	Fair
Bosc	Sept. 1	18	Dec. 20	110	10	Jan. 20	141	7	36°F	Scald and rotting	Good
Bosc	Sept. 10	21	Dec. 25	106	12	Jan. 20	132	10	36°F	Breakdown	Very good
Bosc	Sept. 20	15	Nov. 15	56	8	Dec. 25	96	6	36°F	Breakdown and rotting	Very good
Comice	Aug. 22	20	Nov. 10	80	10	Jan. 10	141	8	32°F	Wilting and scald	Fair
Comice	Sept. 1	21	Dec. 1	91	12	Jan. 10	131	8	32°F	Wilting and scald	Fair
Comice	Sept. 10	21	Dec. 25	106	15	Feb. 20	162	10	32°F	Wilting and scald	Good
Comice	Sept. 21	23	Jan. 15	116	15	Mar. 1	161	10	32°F	Scald	Excel
Comice	Oct. 3	16	Jan. 1	90	10	Jan. 20	109	8	32°F	Scald	Very good
Comice	Aug. 22	20	Oct. 15	54	8	Nov. 25	95	5	36°F	Scald	Fair
Comice	Sept. 21	21	Nov. 1	61	8	Dec. 5	95	5	36°F	Scald	Fair
Comice	Sept. 10	21	Nov. 20	70	9	Dec. 20	100	6	36°F	Wilting scald rot	Good
Comice	Sept. 21	23	Dec. 20	90	10	Jan. 10	111	6	36°F	Breakdown and scald	Very good
Comice	Oct. 3	16	Dec. 1	59	6	Dec. 20	78	4	36°F	Breakdown and rotting	Good
Hardy	Aug. 22	12	Oct. 20	59	9	Dec. 20	110	7	32°F	Wilting	Fair
Hardy	Sept. 1	15	Nov. 15	75	9	Jan. 10	131	7	32°F	Wilting	Good
Hardy	Sept. 10	17	Dec. 1	82	8	Feb. 10	153	6	32°F	Wilting	Good
Hardy	Sept. 21	13	Dec. 25	95	8	Feb. 10	143	5	32°F	Breakdown	Very good
Hardy	Oct. 3	10	Nov. 25	53	7	Jan. 10	99	4	32°F	Rotting	Good
Hardy	Aug. 22	12	Oct. 1	40	9	Nov. 10	80	6	36°F	Scald	Fair
Hardy	Sept. 1	15	Nov. 1	61	8	Dec. 20	110	6	36°F	Scald	Good
Hardy	Sept. 10	17	Nov. 15	66	8	Jan. 10	122	8	36°F	Scald	Very good
Hardy	Sept. 21	13	Nov. 15	55	10	Nov. 25	65	7	36°F	Breakdown	Good
Hardy	Oct. 3	10	Oct. 15	12	7	Nov. 10	38	5	36°F	Rotting	Good

The Bosc is generally described as having a rich golden yellow skin almost entirely covered with a heavy brown, or cinnamon russet. In the lots under observation, however, a marked variation was noted in the pears of the different pickings, with respect to the character and color of the epidermis. Even after ripening, the pears of the first picking were only a pale yellow with but few broken streaks of brown russet on the surface of the skin. The skin also was fairly smooth. In ripened fruits of the third and fourth picking, the color was rich golden yellow, and the epidermis was entirely covered with a cinnamon russet. The pears of the second picking, which was made at the height of the commercial harvest period, were intermediate in character between those of the first and of the third and fourth pickings. The fruit obtained at the first and second pickings was small and insipid in flavor. The fruits of the third and fourth pickings were larger and the quality and flavor were better, the flavor being sweeter and more aromatic and the quality being of the best.

At 32°F. the third and fourth pickings attained the best quality and richest flavor. The optimum and maximum storage dates were latest for the third picking, indicating this picking had been made at the most desirable stage of maturity for storage. The earlier the Bosc was picked, the greater the tendency for the variety to wilt in storage, especially in the long fleshy neck. There was, however, pronounced wilting at 32°F., with specimens of each of the pickings when the stem was injured.

A temperature of 36°F. was less satisfactory for storage of the Bosc than 32°F. The Bosc when picked at the optimum stage of development kept nearly six weeks longer at 32°F., than at 36°F. It is interesting to note, however, that the Bosc specimens picked immaturely had as late an optimun storage date at 36°F., as at 32°F., and likewise kept nearly as well at 36°F., as the third picking.

At 32°F. the Bosc, especially when picked immaturely generally failed from loss of moisture and wilting. The later pickings did not wilt so badly, but the tissue became soft and failure was due to internal breakdown. At 36°F., scald was the principal cause of failure and some rotting developed although the Bosc did not appear to be especially susceptible to the growth of rot organisms.

The third picking of Bosc made about 10 days after the main commercial picking in the Santa Clara Valley attained the most characteristic color, size and general appearance, and kept to the latest optimum and maximum dates in storage.

The first picking of Comice was made when the fruit was relatively immature. The seeds were white and poorly developed, the flavor insipid and the size inferior. The pears of the second picking were also small. They were, however, more colored and did not wilt so badly in storage. The quality attained was likewise better, the flavor being sweeter, and the flesh more juicy, but nevertheless, the pears were below the standard of quality generally possessed by the Comice. While the quality, flavor, texture and juiciness of the pears of the third picking were superior to the previous picking, the size had only slightly increased. The fruit,

however, appeared to be more matured. Comice pears of the fourth picking were well colored, with a rich yellow ground color and a bright reddish overly on one side. The quality and flavor were excellent. The size was nearly double that of the previous pickings, and the fruit was attractive and free from blemishes. The pears of the fifth picking closely resembled the fourth, except that the specimens were more easily bruised and thus gave evidence of being over-ripe when harvested.

The earlier the date of harvest of the first four pickings, the sooner the fruit failed in storage, both at 32°F., and 36°F. The failure of the first three pickings was due largely to wilting and scald. To a less extent scald developed on the fruit of the fourth picking. The fifth picking exhibited the least amount of wilting and scald, but failed in storage as a result of rotting about the bruised areas and softening and breaking down of the flesh.

During certain seasons, the last, or fifth picking of Comice actually kept longer at 32°F., than those made previously. At 36°F., however, the fifth picking always failed in advance of the fourth picking, indicating that over maturity is more serious at 36°F., than at 32°F.

The pears of the fourth picking, made 11 days after the height of the commercial harvest period, were most satisfactory for storage, as indicated by the following characteristics;—(a) maximum weight and size nearly double that attained at the time of the commercial picking; (b) excellent quality, sweet flavor and fine, melting, juicy texture; (c) highly colored, attractive fruit that retained its qualities for over five months in storage at 32°F., and which remained marketable for over two weeks after becoming ripe subsequent to removal from storage.

The first and second pickings of Hardy were undersized. The third picking was of good size, but the fourth and fifth pickings showed a marked increase in size of the fruit. The flavor of the fruit of the different pickings was as follows: first, acid to subacid and insipid; second, sub-acid and aromatic; third, sweet with almost no acidity. The pears of the third and fourth pickings were very juicy.

The quality attained by the Hardy pears stored in 32°F., was superior to that developed in 36°F. The pears stored at 32°F., were more juicy than pears kept at 36°F. At 32°F., the first three pickings failed in storage because of wilting; the fourth and fifth pickings failed from internal breakdown and rot. At 36°F., the first two pickings wilted and showed scald, but all the pickings were inclined to become rotten before wilting resulted.

The commercial picking of the Hardy has, in the Santa Clare Valley, generally been completed by the first of September, or at a time previous to the second picking of the experiment. The fourth picking, made about three weeks after the commercial picking, kept best in storage both at 32°F., and 36°F. The third picking made 10 days after the commercial picking, however, more nearly approached the keeping quality of the fourth picking at 36°F., than at 32°F. The size and flavor of the fourth picking was the best. The first and second pickings were made before the fruit

was sufficiently mature for harvest, as evidenced by the severe wilting, small size, and inferior flavor. The fifth picking, while of large size and good quality was made too late in the season for successful storage as indicated by the rapidity of ripening, breaking down and rotting.

SUMMARY

1. The evidence indicates a tendency to harvest plums in too green a state for the development of the most attractive appearance, largest size, greatest sugar content and most pleasing flavor.

2. The proper stage of ripeness for picking, however, is difficult to determine and it is necessary for each grower to study his own fruit.

3. It is likewise imperative to avoid permitting the fruit to become overripe before harvest, since such fruit much more quickly deteriorates than that somewhat immature, especially at the higher temperatures.

4. The further advanced the maturity when harvested the greater the necessity of careful handling and the avoidance of undue delay in marketing.

5. Three seasons' observations indicate a tendency in sections of California to pick pears before they are sufficiently mature.

6. The evidence shows that immature pears did not keep as well as firm, mature specimens. The texture, flavor, quality, and market value of this immature fruit, does not equal that of the better developed, properly matured fruit.

7. The fruit, however, must not remain on the tree long enough to become overripe. Such fruit is nearer the end of its life limit and consequently deteriorates with even greater rapidity in cold storage than immature fruit.

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Preliminary Report Upon the Influence of Climatic Conditions on the Ripening Processes in Apples

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A QUESTION which is very frequently asked by the commercial fruit grower is "How can I tell when my fruit is ready to pick?" The tests which have been suggested in answer to the above question are the ease with which the fruit separates from the tree, the color of the fruit, particularly the ground color on the side not exposed to direct sunlight, the color of the seeds, the hardness or firmness of the fruit, etc. There have been, however, almost no exact studies as to how these various characteristics of the fruit change as ripening progresses, and there has been little study as to how the ripening processes are affected by climatic conditions.

During the past year investigations have been carried on cooperatively between the United State Department of Agriculture and the state experiment stations at Amherst, Massachusetts; East Lansing, Michigan; Wooster, Ohio; Ames, Iowa; and Columbia, Missouri, in an attempt to gain more definite information upon these ripening processes and upon how these processes vary under varying climatic conditions.

The work was planned from the viewpoint of securing more definite information than any now available upon the following four points: First, what constitutes a reliable test for the determination of the best picking season for our commercial apple varieties. Second, what are the factors involved in the determination of the ripening season for apple in any given locality. We know for instance that the season of ripening of any variety may vary as much as three to four weeks in the same locality, depending upon climatic conditions. Accurate knowledge of the effect of various climatic conditions upon the ripening processes of apples, would enable us to predict the time of ripening fairly accurately in advance of the ripening season, and this would be of great economic advantage. Third, what are the real differences in varieties which determine varietal adaptability to any general region. We know that certain varieties, such as Winesap, Yellow Newtown, Rome Beauty, etc., have been grown with particular success in the Pacific Northwest and in the southern section of the eastern apple growing districts, while other varieties such as Baldwin, Northern Spy, and Rhode Island Greening have reached their highest perfection in the apple districts of the North and East. It is hoped to secure information which will establish more definitely the reasons for the adaptability of certain varieties to particular environmental conditions. Fourth, it was desired to secure a background of information concerning the changes in hardness of the fruit while on the tree, in order that we may have a more intelligent basis for

judging the changes in hardness following removal from the tree. The change in hardness of apples represents the most pronounced change which occurs between the time the fruit is tree-ripe and when it is ready for consumption. A mechanical measure of the changes in hardness of the fruit following removal from the tree appears to be the best measure which we have of the progress of the maturation processes.

METHODS

In order to follow accurately the color changes in the fruit, standard color charts carrying varying intensities of green and yellow color were prepared which correspond fairly closely to the ground color of most varieties of apples at various times during the ripening season. The color of the fruit for any particular date was recorded according to the chart number to which it was most nearly comparable.

Changes in size of the fruit were measured by measuring the largest radial circumference. These measurements were made at 10 day intervals and the volume of the fruit computed on the basis of the apple being a sphere. While this is not entirely accurate the results are directly comparable.

Changes in the hardness of the fruit were measured by means of pressure testers similar in design to the one described by Murneek. The hardness of the fruit with skin intact and the skin removed was measured, the number of pounds required to force the plunger seven-sixteenths of an inch in diameter into the fruit to a depth of five-sixteenths of an inch being recorded. These tests were also made at approximately 10 day intervals.

General notes on the ease of separation from the stem, color of seeds, amount of crop on the tree, etc., were also made in connection with these studies.

SUMMARY OF RESULTS

The changes in size and changes in hardness of fruit from the various states are shown graphically in the accompanying charts, which are self-explanatory. Although these data represent the results of preliminary investigations, certain of the results are so consistent that they may be pointed out at this time with considerable confidence.

It is apparent that in all the varieties studied increase in size continued at very nearly a uniform rate so long as the fruit was attached to the tree. Size of the fruit was very largely associated with the amount of fruit borne on the particular tree from which the fruit was taken, and with the conditions of vigor within that tree. Regardless of whether the fruit was large or small, however, it apparently increased in size at a very uniform rate so long as it was attached to the tree. In the case of Grimes grown at Arlington, Virginia, this held true well into October although the normal picking season for Grimes in that district was around September 20.

Softening of the fruit while on the tree varied considerably in different districts. Apparently the northern grown fruit, particularly that from East Lansing, Michigan, was very much harder during the early season than was that from southern districts.

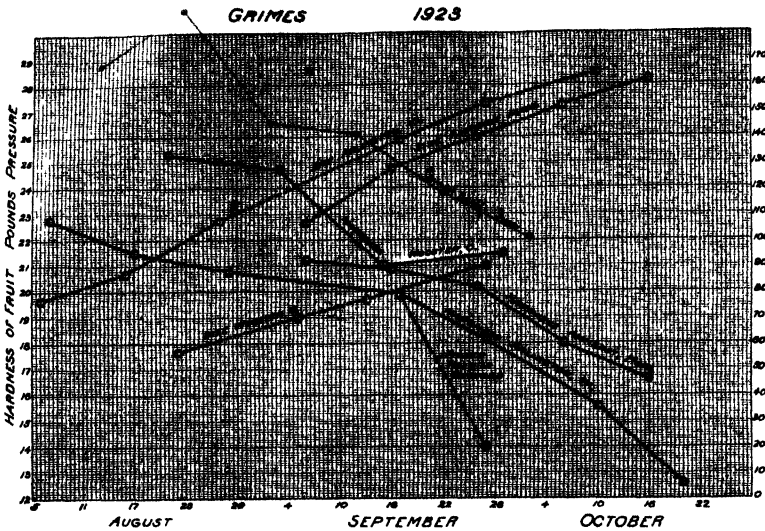

FIGURE 1—Changes in size and hardness, Grimes Apples, 1923

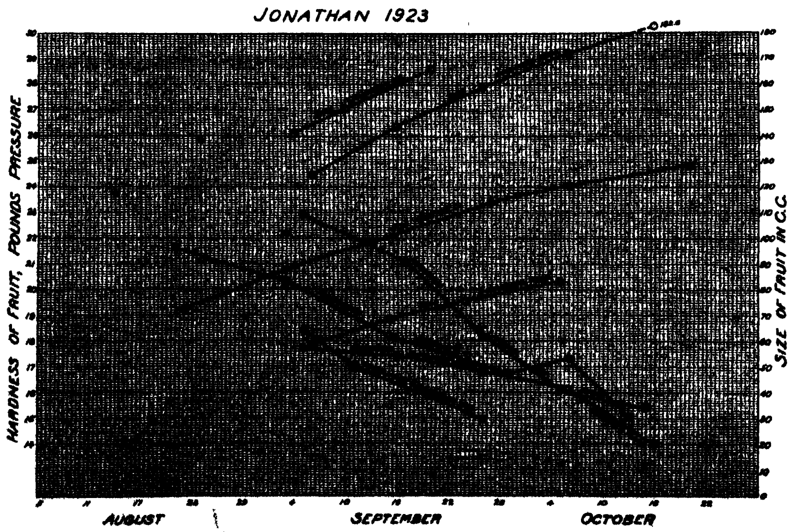

FIGURE 2—Changes in size and hardness, Jonathan Apples, 1923

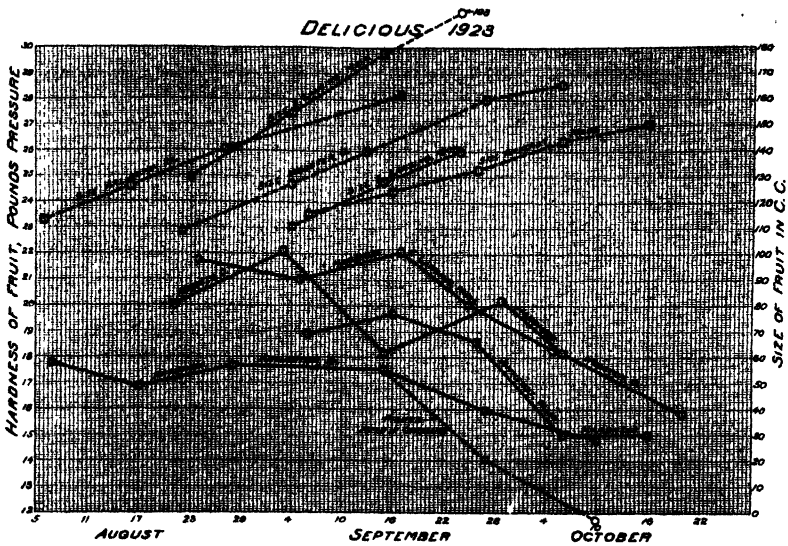

FIGURE 3- Changes in size and hardiness, Delicious Apples, 1923

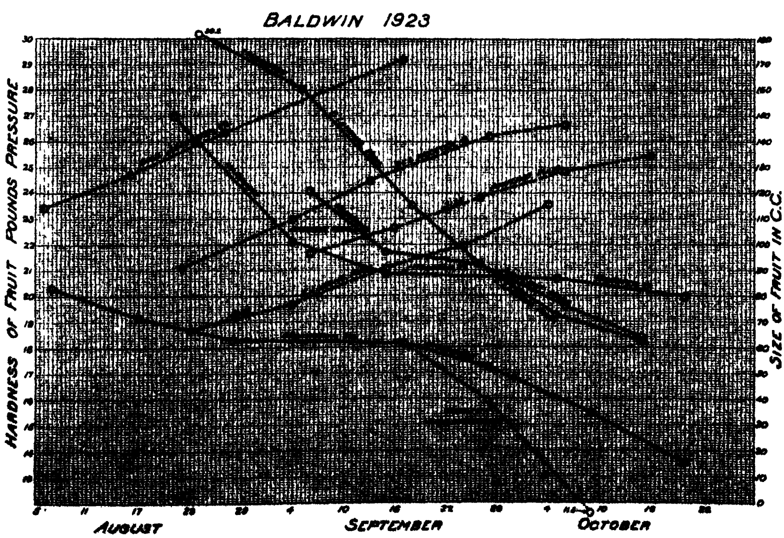

FIGURE 4—Changes in size and hardness, Baldwin Apples, 1923

This is particularly marked in comparing Baldwin, Ben Davis, and Winesap, from East Lansing, Michigan, and from Arlington, Virginia. Northern grown fruit, however, softened rather rapidly, and while it was always harder than that from Virginia at the same time, the differences were less marked by the time the fruit was ready to pick than earlier in the season.

The rate of softening seemed to be rather variable and while these results are preliminary, they indicate that hardness of fruit as a test for picking condition will need to be used with considerable caution. Taken in consideration with other tests, however, it may prove of value in this connection.

Data concerning the changes in color associated with the ripening processes are not given in detail. The results suggest, however, that the changes in the ground color will vary greatly with the particular variety. Baldwin, for example, remained very green as long as it was attached to the tree. This was particularly true of southern grown Baldwin. Very little change in ground color of this fruit occurred even up to the time of dropping. Jonathan, Winesap, Grimes, and Delicious, however, showed very pronounced change, becoming quite yellow with only a tinge of green before being ready to pick. Color development was apparently fairly uniform under the different climatic conditions studied. Ben Davis, at the opposite extreme from Baldwin, showed very little green in the ground color even two or three weeks before the commercial picking season. Indications are that with most varieties the ground color is an excellent test for time of picking, although more study is needed in regard to variation in different varieties, since the same colors cannot be used as a standard for all apples.

In practically all cases seeds become brown two to four weeks before the fruit is ready to pick. This fact indicates that color of seeds may be used to indicate some time in advance of the picking season about when the fruit will be ready to remove from the tree. It cannot be used, however, as a definite test to determine when the fruit is actually ready to be picked.

Fruit of several varieties grown at Arlington, Virginia, was removed from the tree on September 15 and stored in the orchard, being placed in the crotches of the same trees upon which they were produced. The relative rates of softening of this fruit, and that remaining upon the tree, was then determined and are shown graphically in the figures. In all varieties so tested except Ben Davis, softening progressed distinctly faster following removal from the tree than while the fruit was attached to the tree. Ben Davis softened only very slowly when removed from the tree and softened at approximately the same rate while attached to the tree.

It has not been possible to include all the results of even this first year's study in this short discussion. Data from some of the cooperating stations were not received in time to incorporate in this report. It is believed, however, that with the splendid cooperation which has been secured in this preliminary work, and which it is hoped can be continued and expanded during another season, real progress will be made upon these studies on the growth of apples and the changes which are associated with their growth and ripening upon the tree.

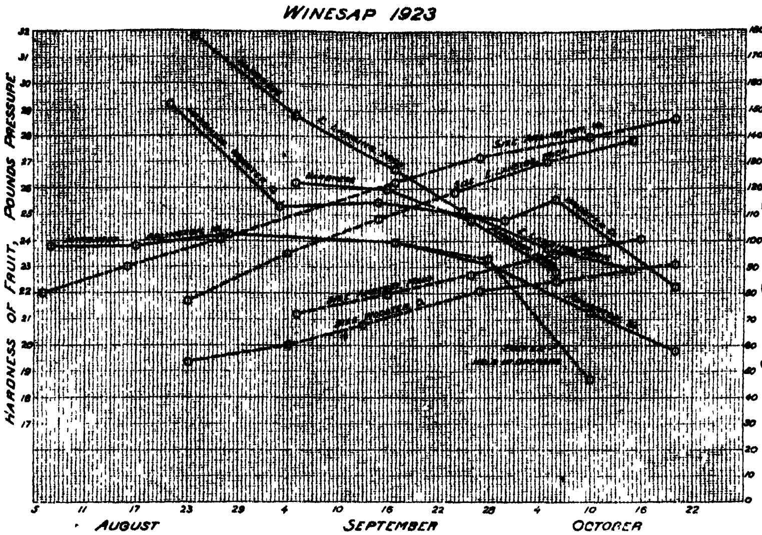

FIGURE 5—Changes in size and hardness, Winesap Apples, 1923

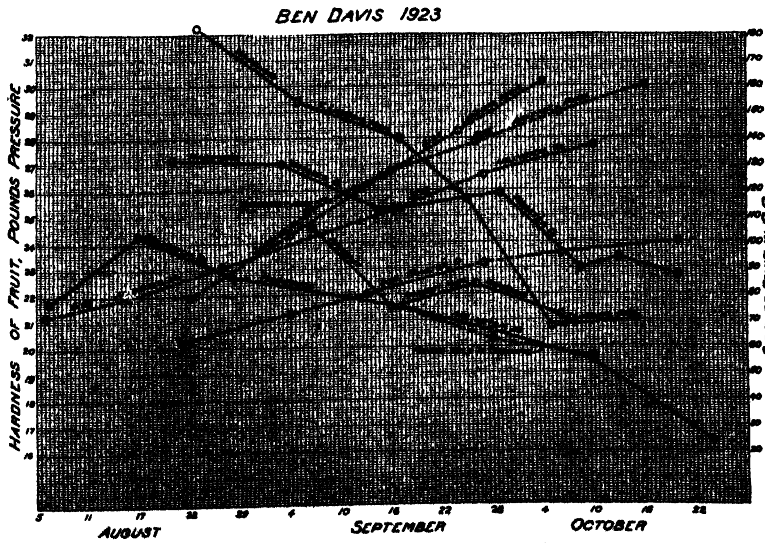

FIGURE 6—Changes in size and hardness, Ben Davis Apples, 1923

Preliminary Report on Grape Breeding in Maryland

By E. C. AUCHTER, AND W. E. WHITEHOUSE, *University of Maryland, College Park, Md.*

INTRODUCTION

GRAPE breeding studies have been carried on at the Maryland Agricultural Experiment Station over a period of 11 years. These investigations were started and conducted by Mr. W. R. Ballard from 1912 until 1918, from which time they have been under the direction of the present authors. At the time this work was started it was hoped that other desirable varieties of grapes, in addition to those varieties available at that time, might be produced. For instance, Moore Early, one of the earliest of our commercial grapes, is not especially productive in Maryland. As a consequence the production of a new variety, which in addition to being as early or earlier, and also as productive, would be a great help to the grape growing industry of the state. Certain of our other standard varieties also have some weak points under Maryland conditions.

OUTLINE OF THE WORK

At the beginning of this work a number of crosses were made between Vitis labrusca and Vitis vinifera. Later, many of the Roger's Hybrids and Vitis labrusca, and in addition those varieties containing Vitis riparia blood, notably Clinton, were used in many of the crosses. Crosses were also made between many of the common sorts such as Winchell, Diana, Worden, Campbell Early and Eclipse. Due to the pressure of other work, it has been impossible to devote the time and energy necessary to carrying this type of work out on an extensive scale. About 1200 seedlings have been raised to date and this paper is in the nature of a preliminary report of the behavior of these seedlings. The following list is an outline of the crosses and of the varieties used in open pollination work, with the number of seedlings secured in each case.

TABLE 1

Varieties Used

Number	Open Pollinated	Number	Crosses
2	Bailey	6	Agawam x Clinton
2	Brilliant	62	Brighton x Winchell
8	Creveling	23	Campbell x Winchell
5	Goethe	146	Clinton x Black Hamburg
14	Lucile	48	Delicious x Winchell
86	Lindley	56	Diana x Clinton
196	Mericadel	61	Diamond x Clinton
4	Red Giant	34	Eclipse x Brilliant
12	Salem	35	Lindley x Clinton
80	Wilder	16	Lindley x Campbell
7	Woodruff	6	Lindley x Winchell
2	Wyoming	22	Moore Early x Winchell
9	Worden	14	Salem x Clinton
...	———	83	Winchell x Clinton
...	———	56	Winchell x Brilliant
...	———	39	Winchell x Worden
...	———	121	Worden x Winchell
...	———	54	Worden x Clinton

Results Obtained

Although very few promising or desirable seedlings have been obtained up to date, still the seedlings from certain variety crosses have stood out in the work, and in a further study of this nature these varieties would be used in preference to many of the others. From the open pollinated varieties used, very few desirable seedlings have resulted. Five of the Lindley, one of the Lucile, and one of the Mericadel, appear at this time to have some promise. In the crossing work, Diamond, Brighton, Clinton, and Winchell, gave the most promise as parents, while Worden, Brilliant, Delicious, and Moore Early, have proved of secondary importance. Palmer (1), Wellington (3), and Hedrich and Anthony (2), found that certain of these same varieties gave desirable seedlings. Of the Diamond X Clinton crosses which have fruited, one, a green grape is promising, having vigor and good quality. Of the Brighton X Winchell crosses, one, a red grape, has exceptionally good quality and berries which hold well to the cluster. Winchell X Worden has given one seedling of promise, a purple grape of good quality. In addition, seedlings have been obtained from Moore Early X Winchell and Winchell X Brilliant which merit further observation before discarding them.

A study of the following table on fruit color inheritance is interesting.

Table 2

Inheritance of Fruit Color in Grapes

Cross	Parent Colors	No. Vines Fruited	Per cent Blue	Per cent Red	Per cent White
Agawam x Clinton	R x B	3	66.6	....	33.3
Brighton x Winchell	R x W	6	....	16.6	83.4
Campbell x Winchell	B x W	4	75.0	....	25.0
Clinton x Black Hamburg	B x B	40	92.5	....	7.5
Delicious x Winchell	B x W	13	15.3	....	84.7
Diana x Clinton	R x B	14	50.0	....	50.0
Diamond x Clinton	W x B	22	54.5	4.6	40.9
Eclipse x Brilliant	B x R	9	66.6	....	33.3
Winchell x Clinton	W x B	25	52.0	....	48.0
Lindley x Clinton	R x B	4	75.0	25.0	.....
Lindley x Campbell	R x B	2	50.0	....	50.0
Lindley x Winchell	R x W	3	....	....	100.0
Moore Early x Winchell	B x W	8	25.0	....	75.0
Salem x Clinton	R x B	4	25.0	....	75.0
Winchell x Brilliant	W x R	17	....	....	100.0
Winchell x Worden	W x B	54	33.3	7.5	59.2
Worden x Winchell	B x W	44	25.0	....	75.0
Worden x Clinton	B x B	7	85.8	....	14.2

Blue and black are classed as one color and all gradations of red as one color. In our work the number of crosses made is small compared to the numbers made by other investigators. Blue appears to be dominant over red. The white color in the majority of the crosses was furnished by Winchell, and apparently the factor or factors carrying the white of this variety, except when used with Campbell, exert a strong dominance.

Palmer (1) found the blue color of Campbell dominant in his Campbell X Winchell crosses, and Hedrick and Anthony (2) and Palmer (1) all found white recessive to blue. In all probability the same results would have been obtained in our work had we used a larger number of white varieties. Apparently, Winchell must be used with discretion in working for a better blue or red colored grape.

Conclusions

From the comparatively small number of seedlings fruited up to date, we have obtained a few which give promise in one or two respects. However, it is questionable if these seedlings have all the qualities necessary to make them better than our present varieties. Our work so far has failed to produce a variety in which earliness, blue color, and good quality, are all present.

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Growth Studies of the Concord Grape

By A. L. Schrader, *University of Maryland, College Park, Md.*

Introduction

WHEN one reviews the literature on the pruning of the grape, it is surprising to not that relatively little experimental work has been done except to test out the various practices which have developed. Although our pruning practices have been largely governed by an apparent relation between the growth and the fruitfulness of the vine, practically nothing has been done experimentally to determine what this relation is. The pruning practice recognizes this relation when the vines are pruned to a limited number of buds so that the vine will not "overbear," and that sufficient growth will be made to furnish fruiting wood in the following year. The aim of the pruner is to maintain a balance between the vegetative growth of the vine and its fruiting capacity. When vines are too strongly vegetative, more buds are left at pruning time with a consequent increase in fruiting and a reduction of the growth. Keffer (1) in Tennessee has found that unpruned canes will bear more fruit than pruned canes, but the shoot growth on the unpruned cane is much reduced with a consequent reduction of the yield in the following season. Since pruning apparently maintains a good individual cane growth which insures annual fruiting of the vine, there must be a relation between the length of the individual cane and the fruitfulness of its buds. Partridge

(3) in Michigan reported data to show that the diameter of the individual cane and its fruitfulness are related. The largest yields were obtained by Partridge from canes of one-quarter of an inch in diameter, or "pencil size." Thus it is suggested at this time that the growth of the individual cane and the fruiting of its buds are related. This suggestion appears to be borne out by our pruning practice which removes about 90 per cent of the new growth of the vine and retains only a few selected canes which are also pruned back severely.

Relation Between the Original Length of the Cane and Its Fruiting

In order to get some measure of the above relation, some studies were made in one of the College vineyards at College Park. Fifty canes were measured at pruning time to get the original length of the cane before pruning. Canes of various lengths were used ranging from three to 12 feet. The diameter of the canes was approximately "pencil size," such as a grower would select. All of the canes were then pruned to 12 buds each. Table I shows the average yields per cane that were obtained from the canes arranged according to the original length of the cane.

It can be seen from Table I that the canes which had three to four feet or original length produced a comparatively low average yield. Canes which had an original length of four to seven feet bore the largest yields. The canes of the longer original length show a decreasing of yield with greater length of cane. Despite the small number of canes used in this test, the results on average yields per cane appear significant as shown by the probable errors given in the table. The large yield of the four to five foot class is due especially to the greater number of bunches per cane, as shown in Table I, together with a fairly good size bunch. The greater number of bunches on the canes of this class is probably a chance variation in the material of the test, since the number of bunches per cane appears to be nearly constant for the other classes. The eight to 12 foot class shows a slight drop in number of bunches per cane which can be ascribed to the large percentage of buds which did not start on this type of cane. The low average yield of these long canes is likewise due especially to the large percentage of buds which did not start, and also to a lower weight of bunch than the high yielding canes of the five to six and six to seven foot classes. It might be thought that the *fruiting buds* of these long canes would show a larger average yield than the fruiting buds of the high yielding canes, due to the fewer number of buds which produced the yield on the long canes, but Table I shows that this is not the case. The average yield per *fruiting bud* on the long canes is relatively low as compared to those of the high yielding canes. This is due largely to the relatively low average weight of bunch on these long canes, since the number of bunches per shoot was about the same as the number on the high yielding canes. On the basis of greater weight of bunch and large total yield, it is evident that the five to six foot class of canes represents the most desirable length of canes used in this experiment.

TABLE I

Influence of Original Length of Cane Growth on the Fruiting of Canes Pruned to 12 Buds.

Original length of cane in feet	3-4	4-5	5-6	6-7	7-8	8-12
Number of canes averaged	8	10	8	7	4	9
Average yield per cane in one-half ounces	124±7.2	160±7.4	159±4.7	153±12.2	138±4.6	128±5.1
Average yield per fruiting bud in one-half ounces	12.1	15.2	15.6	15.8	13.7	14.1
Per cent of buds not starting	14.5	12.5	16.6	19.0	16.6	24.1
Average weight of bunch in one-half ounces	4.5	5.2	6.0	5.8	5.0	5.4
Average number of bunches per cane	25.6	30.3	25.0	25.7	25.0	23.2

Differences in yield per cane 159-124=35±8.8
159-138=21±6.6
159-128=31±6.9

To sum up the data in Table I it appears that under Maryland conditions, the "pencil size" of cane may vary in its productiveness, depending upon the original length of the cane.

Although the data given in Table I were obtained in one season from "pencil size" canes on vines of ordinary vegetativeness for Maryland conditions, there is a suggestion that these data were governed by some general relations between the growth of the cane and its fruitfulness, for a given condition of the vine. These relations are tentatively suggested at this time as follows:

I. *Strongly vegetative canes have buds of low fruiting capacity.* The extreme of this type of cane is typified by the so-called "bull cane" which has been observed to be non-fruitful.

II. *Medium vegetative canes have buds of maximum fruiting capacity.* The actual length of this type of cane will probably vary according to the vegetativeness of the vine, but it will be medium vegetative for the vine in question. Thus a medium vegetative cane on one vine may not be the same length as a medium vegetative cane on another vine. Under the particular conditions of the above experiment, the five to six foot length appeared to represent this type.

III. *Weakly vegetative canes have buds of low fruiting capacity.*

The above three types are probably not sharply defined, but merge into one another. It will be noted immediately that the canes used in this experiment merely approach the extremes suggested by Types I and III.

The Point of Optimum Yield on a Cane Pruned to 12 Buds

The above studies brought out data as to the point of optimum yield on a 12 bud cane under the conditions of the experiment. According to the work of Keffer (1) in Tennessee, the fourth to sixth buds on a 12 bud cane were the most fruitful. Some unpublished work by H. W. Richey (4) in West Virginia and Maryland, also showed the optimum yield from buds along the middle of the pruned cane. Partridge (2), in Michigan, reported data to show that the fourth bud was the point of optimum fruiting. Later, Partridge (3) found that the vegetative condition of the *vine* influenced the point of optimum yield. *Vines* growing on sand in Michigan showed an optimum production at the eighth bud. *Vines* growing on medium loam had an optimum at the ninth bud. *Vines* growing on heavy loam in Michigan had no point of optimum production on a 15 bud cane, but the buds increased in productiveness from the base to the tip of the cane.

The data from the Maryland experiments show that the optimum yield on a 12 bud *cane* appeared at the fourth bud. These data are shown in Table II.

The results in the above table agree in general with the results obtained by Richey (4), Partridge (2), and Keffer (1), previously cited. The data in Table II also indicate that the point of optimum yield remains at the fourth node regardless of the original length of the *cane*. This peculiar indication emphasizes the influence of the vegetative condition of the *vine* on the point of optimum production of the *cane*. All the vines used in the experiment were about in the same vegetative condition. It is probable that the above workers had about the same vegetative condition of vines, and probably would have found little influence of original length of cane ("pencil size" in diameter), on the point of optimum yield with vines in this vegetative condition.

Pruning Young Vines

Some studies were also made on the pruning of the young vine. The usual practice in bringing young vines into bearing condition has been to remove all the top growth at planting time except a short piece of a cane bearing two buds. This severe pruning is repeated at the beginning of the second season and sometimes even again at the beginning of the third season of growth. Finally after these two or three severe prunings a part of a single cane of the vine is used to form the trunk of the vine. The question arose as to the merits and the advisability of so much pruning of the young vine which delayed the bearing age of the vineyard. Therefore, in 1922, three methods of pruning were tried out in a young vineyard at College Park. The vineyard consisted of 96 vines which had been planted in 1921, at which time the usual method of pruning to two buds was used on all vines. A good growth was made in 1921 due to an application of manure and the fertile soil. In the spring of 1922, three methods of pruning were started. In method 1, 45 vines were again pruned back to two buds according to the usual practice, but only one shoot was allowed to develop. In method 2, 24 of the vines had all the top growth removed except a single cane which was pruned to a length to form a trunk to the top wire of a two wire trellis. Method 3 was similar to method 2, except that a cane was used to form a trunk to the lower wire. In all methods the sucker growth was kept from developing on the lower part of the vine. The results obtained from the three methods were as follows:

Method 1. The one shoot grew very vegetatively on all vines, and produced several lateral shoots. Thus in 1923, the vines had a complete frame-work by using the laterals for fruiting wood. The four cane Kniffin system of training was used. In spite of the very vegetative condition of the vine, these laterals produced an average of 18 pounds of fruit per vine, or a calculated yield of about five tons per acre (544 vines per acre). The growth of 1923 was also good which promises a full crop for 1924. Thus this method brought the vines into

TABLE II

Average Yield per Bud on a 12 Bud Cane, Calculated on a Percentage Basis*

Number of shoot numbering from base of cane	1	2	3	4	5	6	7	8	9	10	11	12
3-4 foot canes	67	82	75	100	97	44	99	80	65	70	50	75
4-7 foot canes	53	80	90	100	84	58	68	52	72	74	84	73
7-12 foot canes	52	104	52	100	58	69	81	65	86	70	83	73
All canes	69	86	77	100	79	59	76	75	75	72	78	73
Average yield per shoot of all in one-half ounces	10.8	13.5	12.1	15.7	12.4	9.2	11.9	11.6	11.8	11.3	12.3	11.5

* All buds considered in average. Includes buds that did not start.

full bearing in the third season of growth. The fruitfulness of laterals in this case agrees with the work of Partridge (3).

Method 2. No crop was produced in 1922 due to a frost, but some records obtained on similar vines in 1923 shows that about three pounds per vine can be expected in the second season under this method. These vines developed strongly growing shoots in 1922, which formed good fruiting canes for 1923. The framework was thus complete, and the vines were pruned to the four cane Kniffin system, in the spring of 1923. The vines yielded an average of 17 pounds per vine in 1923, or about four and one-half tons per acre. The growth of 1923 was also good, which means no diminished crop for 1923.

Method 3. These vines also produced good growth in 1922, but the frame-work was only partially complete. In the spring of 1923, one cane was used to extend the trunk to the top wire and two canes were laid down on the lower wire. Thus the vines possessed a complete trunk and two fruiting canes instead of four. The yield in 1923 was 12 pounds per vine, or about three and one-fourth tons per acre. The vines will be in full bearing condition in 1924.

The above results in pruning young vines show that strongly growing vines can develop a complete frame-work of full bearing capacity in two seasons of growth. Either of the first two methods appear adapted to produce the result. The third method would perhaps be desirable for vines less strongly vegetative.

Root Studies

An objection might be raised, that the method which brings up a cane on the trellis at the end of the first growing season might reduce the root system, since advocates of the severe pruning outlined previously maintain that the root system must be developed by keeping the top reduced. Root studies in Maryland indicate the root development of young vines after two years' growth, is not increased by the severe pruning of the tops. The root-top ratio (roots divided by top) appears to vary inversely with the length of growth made by the top. Further and more complete root studies along these lines are in progress.

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Cross Pollination Between the Reine Claude and Burbank Plums

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It is not the purpose of this paper to consider the inter-sterility problem in its broad and more fundamental aspects, nor to review the rather extensive literature on the subject. It is merely to put on record an experience with the pollination of the Burbank and Reine Claude plums, which may be of interest to those interested in the plum sterility problem.

In the orchard of the New York State Agricultural Experiment Station at Cornell, there is a row of 20 Burbank plum trees extending approximately east and west. The next row to the north is Reine Claude and north of that a row containing 10 trees of Abundance at the west end and 10 trees of Bradshaw at the east end. To the south of Burbank is a row of Shropshire Damson and beyond that a row of German Prune. Working with these same trees in 1919, A. H. Hendrickson of the California Experiment Station, found that the two varieties, Reine Claude and Burbank, showed evidence of being inter-fertile, a condition contrary to the data given by Marshall working at the Oregon Station, or by Hendrickson in his later work in California. In both of these researches it was shown that *Prunus triflora* and *Prunus domestica* were, with few exceptions, inter-sterile.

The method used by Henderickson was to emasculate and bag the flowers to be pollinated, and as reported in the report of the sixteenth annual meeting of this Society, the number of flowers pollinated was comparatively small, involving only 316 flowers in the case of the Burbank pollinated by Reine Claude, and 322 in the opposite cross. It was suggested by Dr. W. H. Chandler, that, owing to the proximity of the Reine Claude and Burbank trees, there would be an excellent opportunity to test out the intersterility between these varieties under more natural conditions by enclosing a tree of each of the two varieties in a mosquito netting tent with a hive of bees, as had been done in some other pollination experiments, and, in case fruits were produced, to test the viability of the seeds.

The trees in question were about 12 years old, and so large and vigorous that they had to be cut back rather severely on one side to be enclosed in a frame 32x12x14 feet. This was covered with mosquito netting and otherwise made insect proof. At blossoming time a small colony of bees was placed in the enclosure to assure cross pollination. As checks, two branches on each tree were enclosed in cheese cloth bags and a number of smaller twigs on each in paraffined paper bags such as are frequently used in pollination experiments. Both trees blossomed normally and no serious frosts occurred. Much of the weather during blossoming time was cold and

unfavorable for bees to fly. There was, however, at least one-half day when normal flight took place.

Soon after the petals had fallen it became evident that at least a small crop had set on the Burbank tree and a nearly normal crop on the Reine Claude. As would be expected from the recognized self-sterility of the Burbank, no fruit set in either the cheese cloth or the paper bags. The Reine Claude set no fruit in the paper bags and few in the cheese cloth bags as compared with the rest of the tree. In both cases it is likely that there was imperfect pollination within the bags in lieu of either insects or hand pollination.

The weight of fruit on the enclosed Burbank tree and adjoining trees in the same row and adjacent rows is given in Table I.

TABLE No. I

Weight in Pounds of Fruit from Shropshire Damson, Burbank and Reine Claude Trees

Tree	Shropshire Damson		Burbank					Reine Claude				
	Average weight of 50 plums	Weight total crop average	Thinned off average weight of 50 plums	Thinned off total weight	Picked average weight of 50 plums	Picked total weight	Total crop weight	Thinned off average weight of 50 plums	Thinned off total weight	Picked weight of 50 plums	Picked total weight	Total crop weight
*2	...	.....	....	.....	7.62	68.4	68.4	...	....	...	.....	.....
†3, 4, 5	.86	150.3	0.56	100.9	3.10	339.5	440.4	.62	43.9	2.8	140.4	184.3
6, 7, 8	.86	128.8	0.63	112.0	2.90	265.5	377.5	.70	40.8	2.7	168.2	209.0
9, 10. 11	.80	228.5	0.71	111.3	3.30	281.2	392.5	.80	33.7	2.7	145.5	179.0
12, 13, 14	.83	189.5	1.00	115.1	3.60	269.1	384.2	.85	20.3	2.7	116.4	136.7
15, 16, 17	.86	128.8	1.17	117.1	4.00	272.7	389.8	.71	38.8	2.2	141.9	180.7
18, 19. 20	.75	156.1	1.35	91.1	4.95	238.5	329.6	.78	41.4	2.6	156.9	198.3
20 alone	.75	120.2	1.75	66.7	5.90	184.6	251.3	.82	50.6	3.0	150.0	200.6

*Tree 2 was covered with netting in case of Burbank and Reine Claude.

†Trees are grouped in sets of three because these sets had had similar treatment in the pruning experiment for which the trees were being grown.

From the above figures it can be readily seen that the fruit on the enclosed Burbank tree averaged much larger than on any of the others. The fruit was of two types, one very large and perfectly normal except possibly for a very small seed in comparison with the thickness of the flesh; the other type, making up only two or three per cent of the number were very small and in many cases not of typical form. The large size of the fruits might easily be explained by the fact that there were so few on the tree in comparison with the open-pollinated trees. Thinning on the latter trees was accomplished too late to have its maximum affect on the size of the fruit. At the other end of the Burbank row, where the initial set was lighter, the size of the fruits approached more nearly that of the enclosed tree.

It would appear then, that the Burbank and Reine Claude are at least inter-fruitful, using the term in the sense that cross pollination between the two varieties caused the fruit of the Burbank to stick and mature without necessarily producing viable seeds. To determine the germinating quality of the seeds all the 496 Burbank seeds were saved, as were also about an equal number of the Reine Claude seeds. In order to increase the chances of getting seedlings, half of each lot was given to Mr. H. B. Tukey of the New York State Experiment Station at Geneva for germination. It was hoped that a considerable number of seedlings would be obtained which would be hybrids between the two species. From all the seeds, however, only one seedling appeared and that was from a Burbank seed. The natural conclusion would be that the two species were intersterile in the true sense, in that no viable seeds were produced. This is not so certain, however, because, at best, the germination of plum seeds is an uncertain procedure with many chances of failure. On opening 10 seeds of the caged Burbank prior to stratification, six shrivelled embryos and four only partially filled out were found. Aside from being small the embryos seemed normal. As shown by Marshall it is a frequent condition to have only a small proportion of plum stones contain well developed embryos. This was found to be true in case of the open pollinated Reine Claude seeds in which 80 seeds showed 39 shrivelled embryos and 41 normally plump.

One of the chief difficulties in growing Burbank plums in New York State, is that where they are planted with other Japanese varieties, they tend to overbear and require much thinning to produce high grade, marketable fruit. This is more expensive than the value of the crop usually warrants. In the inter-fruitfulness of Reine Claude and Burbank, there is a suggestion that varieties of *Prunus domestica* might be found that would pollinate the Burbank sufficiently well to give a satisfactory crop of large plums and still not require thinning. This is further suggested in the Cornell orchard by the fact that the trees at the east end of the Burbank row away from the Abundance do not set as heavily as, and bear larger fruits than, those at the west end which are near the row of Abundance plums. This progressive increase in size of the plums on the Burbank trees was easily observable in passing along the row from the west end near the Abundance trees to the east end where

there were no trees of the Abundance or other Japanese variety in proximity. This is also substantiated by the data given in the table above. That the increases in size and lighter set of the Burbank was not due to soil or other orchard conditions, is also shown in the data, for no such differences appear in the adjacent rows of Shropshire Damson and Reine Claude.

Su:

(1) Burbank pollinated by Reine Claude produced a fair crop of large, high quality fruits thus showing that the two species are inter-fruitful. (2) Attempts to germinate seeds of either cross practically failed, indicating self-sterility in the true sense. (3) It is suggested that varieties of *Prunus domestica* may be found that will pollinate the Burbank well enough to give a satisfactory set of fruit on the Burbank, without the necessity of thinning.

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Fruit Spur Growth and Fruit Bud Production *

By E. C. Auchter and A. L. Schrader, *University of Maryland, College Park, Md.*

Introduction

CONSIDERABLE interest has been shown during the past few years in a study of fruit spur growth and fruit bud production. In addition to the large amount of valuable information which has accumulated from these studies, probably one of the greatest values of the work has been its influence in causing investigators, and especially fruit growers, to study more closely the fruiting parts of a tree. While making these studies it has been only natural to observe other general growth conditions in the tree. As a result, the general relations of growth to fruiting have been noted, and a better basis for understanding the effects of pruning, fertilizing, spraying and soil management has been afforded.

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Fruit Spur Studies

Although many horticulturists have realized for a long time the importance of the effects of certain common orchard operations on fruit spur performance, and have written concerning such effects, still most of the detailed fruit spur studies, in this country at least, have been comparatively recent. Thus the studies of Yeager (19), Kraus (11), Magness (13), Wiggans (18), Gourley (4), Heinicke (7) (8), Auchter (1), Roberts (17), Harvey (5) (6), Murneek (5) (16), Hooker (10), Hooker and Bradford (9), Crow (2), Crow and Eidt (3), Maney and Plagge (14) (15). Mack (12), and several others have been made within the last 10 years.

The length of this paper will not allow a review of the above literature. It would be especially interesting, if time would permit, to summarize the different studies and ideas concerning the individuality of the fruit spur. Much interest has recently been aroused concerning to what extent fruit spurs act individually as units, and to what extent they are influenced by the tree as a whole, resulting in more or less of a mass action with the tree acting as a unit.

The recent studies of Roberts (17), which have emphasized the association of spur lengths and spur performance, are of especial interest in this connection.

In general Roberts (17) found under his conditions in Wisconsin, four rather distinct classes of spurs based upon their length and performance. He limited the term spur to growths of not more than 65 millimeters, or about two and one-half inches. His classes of spurs and their average lengths follows:

1. Terminal leaf buds (short spur class), average length 2.55 mm., one-eighth inch.
2. Blossom buds (non-fruiting spurs), average length 4.28 mm., about three-sixteenth inch.
3. Blossom buds (spurs which set fruits), average length 12.14 mm., one-half inch.
4. Leaf buds (long spur class), average length 18.14 mm., three-fourths inch and over.

He states, "The classes of spurs are not absolute, instead they blend into each other. In general, however, the medium length spurs form blossom buds, while the shortest spurs rarely do and many of the longest spurs have terminal leaf buds."

Of course the exact length of each group of spurs would vary somewhat with the variety, vigor, and season but the spur lengths of the different groups would hold about the same relation to one another as outlined above.

He finds that these general relations hold with Wealthy, Oldenburg, McIntosh, Fameuse, Yellow Transparent and Northwestern Greening. He states that he has observed the same relation in Jonathan, York Imperial and Winesap in Indiana, Illinois and Missouri.

Recent Fruit Spur Studies at Maryland

Some fruit spur studies have been made at College Park, Maryland, during the period of 1919 to 1923. The material to be pre-

sented in this paper represents the results of such studies on Stayman Winesap, York Imperial, Wealthy, Grimes and Rome Beauty apples. A fruit spur project as related to biennial bearing has also been under way in Maryland since 1920, in cooperation with Roberts of Wisconsin, but the data of this project will not be discussed in this paper.

We are offering our results at this time not because we feel that we have a great deal to add to what has already been published by Roberts (17), Hooker and Bradford (9) and others; but our results indicate that possibly certain spur relations have been overemphasized in some publications, and that certain other relations which might occur under different sets of conditions have not been stressed enough.

In addition, it appears to be highly desirable at this time to draw especial attention to some specific relations of growth to fruiting under different conditions, because it is felt that many young horticulturists who may not have given much thought to fruit spur studies, have had difficulty in finding certain apple spur correlations which they thought *always existed* regardless of conditions or tree.

Likewise the better fruit growers, many of whom are keen observers, have found that certain spur growth relations which they expected to find on their trees, after reading articles and bulletins on the subject, did not exist.

These experiences of growers and professional men do not necessarily mean that the articles which were read were incorrect, but that apparently more emphasis had been placed on certain phases, and that as a result the importance of many of the exceptions was overlooked by the readers.

Types of Spur Growth and Fruiting Condition of Tree

As a result of some of our studies, we believe that it is important to keep spurs, which are similar in type of growth and performance, in classes by themselves. It can easily be done when the measurements are taken. It is also important to know and record the bearing condition of the tree as a whole. Thus if it is in an annual bearing condition it should be noted. Likewise, if it is in a biennial bearing condition, it is important to know whether the tree is in the "off" year or "on" year when the measurements are taken. More attention to a knowledge and statement of these facts will help greatly in an interpretation of the results.

Types of Spur Growth

In the Maryland experiments, we divide the different spurs, which are measured, into five groups, depending upon the kind of growth made during the year in which they are measured. Thus we have; (1) continuous non-blossomers or barren spurs, generally making a short terminal vegetative growth each year; (2) non-blossoming spurs making a terminal vegative growth, that is, leaf buds are formed = (Term. Veg.); (3) non-blossoming spurs making terminal growths which blossom and may fruit = (Term. B. & F.); (4) blossoming spurs making a secondary or side vegetative growth, leaf buds are formed = (Sec. Veg.); (5) blossoming spurs making

a secondary or side growth upon the terminal of which fruit buds are formed = (Sec. B. & F.).

Length measurements of terminal growths at the ends of the main limbs are *not* averaged in with any spur measurements at Maryland.

We have limited the term, or word, "spur," in this paper, to one whose yearly growth did not exceed three inches (76 mm.). Spurs on sections younger than three year wood were not included.

It is not uncommon to find trees which have a large number of continuous non-blossoming, or barren spurs. The yearly growth of such spurs is generally quite small. It can be seen that such spurs really make a terminal vegetative growth. If such spurs are added in with the "Term. Veg." spurs it can be seen that a wrong idea of spur lengths for the "Term. Veg." class might be obtained. (Tables I and II).

TABLE I

1920 Spur Growth and 1921 Performance Record of a 15 Year Old York Imperial Tree. This Tree Was in an Annual Bearing Condition at this Time. Continuous Non-Blossoming Spurs are Added in with the Terminal Vegetative Group

Length of Spur Growth in 1920.	Vegetative and Reproductive Performances in 1921 (York Imperial).								
	Continuous Non-Blossoming and *Term. Veg.		*Term B. & F.		*Sec. Veg.		*Sec. B. & F.		Total Number of Spurs
Length in mm.	Number of Spurs	Per cent	Number of Spurs	Per cent	Number of Spurs	Per cent	Number of Spurs	Per cent	
1	7	100.0	0	0.0	0	0.0	0	0.0	7
2	88	88.0	9	9.0	3	3.0	0	0.0	100
3	120	75.0	26	16.2	12	7.5	2	1.1	160
4	99	52.3	77	40.8	11	5.8	2	1.1	189
5	65	40.9	89	55.9	4	2.5	1	.7	159
6	36	23.5	111	72.5	5	3.3	1	.7	153
7	55	36.2	95	62.5	2	1.3	0	0.0	152
8	50	35.0	87	60.8	4	2.8	2	1.4	143
9	17	25.0	48	70.6	3	4.4	0	0.0	68
10	14	21.2	49	74.3	2	3.0	1	1.5	66
11	8	27.0	22	73.0	0	0.0	0	0.0	30
12	6	24.0	19	76.0	0	0.0	0	0.0	25
13	5	25.0	15	75.0	0	0.0	0	0.0	20
14	2	25.0	5	62.0	1	13.0	0	0.0	8
15	4	40.0	6	60.0	0	0.0	0	0.0	10
16	1	20.0	4	80.0	0	0.0	0	0.0	5
17	0	0.0	4	100.0	0	0.0	0	0.0	4
18	1	25.0	2	50.0	0	0.0	1	25.0	4
19	0	0.0	5	100.0	0	0.0	0	0.0	5
20	0	0.0	2	100.0	0	0.0	0	0.0	2
21	0	0.0	1	100.0	0	0.0	0	0.0	1
22	1	33 0	2	67.0	0	0.0	0	0.0	3
23	1	50.0	1	50 0	0	0.0	0	0.0	2
24	0	0.0	1	100.0	0	0.0	0	0.0	1
25	0	0.0	2	100.0	0	0.0	0	0.0	2
26	0	0.0	1	100.0	0	0.0	0	0.0	1
27	0	0.0	0	0.0	0	0.0	0	0.0	0
28	0	0.0	0	0.0	1	100.0	0	0.0	1

*Term. Veg.=Terminal vegetative spurs. (Growth was terminal, leaf buds formed).
*Term. .B & F.=Terminal blossoming spurs. (Blossoms might or might not set).
*Sec. Veg.=Secondary vegetative spurs. (Secondary growths, leaf buds formed).
*Sec. B. & F.=Secondary blossoming spurs. (Secondary growths, blossom buds formed).

TABLE II

*Record of Same Tree in Same Year as Given in Table I. In This Table, the Continuous Non-Blossoming Spurs have been Placed in a Separate Class. Note the Change in Percentages in the Shorter Lengths of the Terminal Vegetative Spurs as Compared to those in Table I**

Length of Spur Growth in 1920.	Vegetative and Reproductive Performances in 1921. (York Imperial).										
	Continuous Non-Blossoming		Term Veg.		Term B. & F.		Sec. Veg.		Sec. B. & F.		Total Number of Spurs per tree
Length in mm.	Number of Spurs	Per cent	Number of Spurs	Per cent	Number of Spurs	Per cent	Number of Spurs	Per cent	Number of Spurs	Per cent	
1	7	100.0	0	0.0	0	0.0	0	0.0	0	0.0	7
2	78	78.0	10	10.0	9	9.0	3	3.0	0	0.0	100
3	90	56.2	30	18.8	26	16.2	12	7.5	2	1.2	160
4	46	24.3	53	28.0	77	40.7	11	5.8	2	1.2	189
5	11	6.9	54	33.9	89	55.9	4	2.5	1	0.8	159
6	1	0.7	35	22.8	111	72.5	5	3.2	1	0.8	153
7	5	3.2	50	32.3	95	62.5	2	1.3	0	0.0	152
8	0	0.0	50	34.9	87	60.8	4	2.8	2	1.5	143
9	0	0.0	17	25.0	48	70.5	3	4.5	0	0.0	68
10	0	0.0	14	21.2	49	74.2	2	3.1	1	1.5	66
11	0	0.0	8	26.6	22	73.4	0	0.0	0	0.0	30
12	0	0.0	6	24.0	19	76.0	0	0.0	0	0.0	25
13	0	0.0	5	25.0	15	75.0	0	0.0	0	0.0	20
14	0	0.0	2	25.0	5	62.5	1	12.5	0	0.0	8
15	0	0.0	4	40.0	6	60.0	0	0.0	0	0.0	10
16	0	0.0	1	20.0	4	80.0	0	0.0	0	0.0	5
17	0	0.0	0	0.0	4	100.0	0	0.0	0	0.0	4
18	0	0.0	1	25.0	2	50.0	0	0.0	1	25.0	4
19	0	0.0	0	0.0	5	100.0	0	0.0	0	0.0	5
20	0	0.0	0	0.0	2	100.0	0	0.0	0	0.0	2
21	0	0.0	0	0.0	1	100.0	0	0.0	0	0.0	1
22	0	0.0	1	33.3	2	66.7	0	0.0	0	0.0	3
23	0	0.0	1	50.0	1	50.0	0	0.0	0	0.0	2
24	0	0.0	0	0.0	1	100.0	0	0.0	0	0.0	1
25	0	0.0	0	0.0	2	100.0	0	0.0	0	0.0	2
26	0	0.0	0	0.0	1	100.0	0	0.0	0	0.0	1
27	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
28	0	0.0	0	0.0	0	0.0	1	100.0	0	0.0	1

* For instance, of the 100 spurs which made a growth of 2 mm. in 1920, 78 made a terminal vegetative growth but were in the continuous non-blossoming class, 10 made a terminal growth forming leaf buds=(Term. Veg.), 9 made a terminal growth and formed blossom buds=(Term B. & F.), 3 made a secondary growth and formed leaf buds=(Sec. Veg.) and there were no secondary growths forming blossom buds=(Sec. B. & F.).

With a large number of the continuous non-blossoming spurs included in the "Term. Veg." class, this latter class appears to include a large percentage of the total spurs which make growths of only one to three millimeters. Thus 100 per cent of the spurs with a growth of 1 mm., 88 per cent of those with a growth of 2 mm., and 75 per cent of those with a growth of 3 mm., appeared to be in the "Term. Veg." class, that is, did not form fruit buds.

However, when the continuous non-blossoming spurs are put in a column by themselves, it can be seen (Table II) that the "Term. Veg." class includes a much lower percentage of the short growths of one to three millimeters. In fact the percentages of 100 per cent, 88 per cent, and 75 per cent mentioned above, now appear to be 0 per cent, 10 per cent and 18.8 per cent for the "Term. Veg." class where the growth lengths range from one to three millimeters. It can also be seen that these short growing spurs of the "Term. Veg." class (Table II) form fruit buds and leaf buds in about equal percentages. However, those spurs with lengths of four millimeters or longer have much higher percentages of fruit buds formed.

Thus since some trees under some conditions may have a large number of continuous non-blossoming spurs, such as shown in Tables II and V, and others may have relatively few as shown in Table VI, and since these may greatly influence the percentages of certain classes, we believe that they should be kept in a group by themselves. Records showing the variability of the number of continuous non-blossoming spurs on different varieties under different conditions are also shown by Auchter (1) in Table VIII.

The secondary vegetative class (Sec. Veg. in tables) of course occurs only when the spurs have blossomed and have or have not set fruit. A biennial bearing tree will have a large percentage of these produced in the crop year, and may have practically none in the off year.

The secondary blossoming and fruiting class, (Sec. B. & F. in tables) are as a rule small in numbers, under normal conditions. It has been shown by Auchter (1), Roberts (17), Crow (2) and others, that if the blossoms set until the June drop, such spurs seldom form fruit buds on the secondary growths. However, if the blossoms do not set at pollination time, or are removed by artificial means, or by natural means such as frosts, such spurs may, and often do, form a large percentage of fruit buds on secondary growths. In such cases the successive blossoming of spurs is of course high.

Effect of Blossom Removal on Successive Blossoming

Additional evidence to that already published by the Maryland Station on the above facts were secured in 1919 and 1920. The blossoms of 150 spurs were removed by clipping while in the "pink stage" form from a bearing Stayman Winesap tree about 15 years old. The blossoms of 150 other spurs on the same tree were removed by clipping when the petals were fully expanded. Fruits were removed from other spurs after the June drop. In addition, many non-blossoming spurs were labelled and also many spurs

which matured fruit. This work was all done on the same tree in 1919. The tree was bearing a light to medium crop.

In 1920, these different groups of spurs responded as follows:

	Percentage blossoming in 1920 (successive blossoming except 1st group)
Non-blossoming spurs in 1919,	50
Blossoms removed at pink in 1919,	37
Blossoms removed at full bloom,	32
Fruits removed at June drop,	5
Fruits removed at harvest,	1

It can be seen that blossom removal up to full bloom resulted in successive blossoming in about 35 per cent of the cases. This is quite a high percentage when it is noted that only 50 per cent of the non-blossoming spurs blossomed in 1920.

Spurs from which the blossoms had been removed early made a longer secondary growth and had a greater leaf area than those which set and held fruits until the June drop. Thus the average length of the secondary growths on the clipped spurs was 22.2 millimeters, while that of the unclipped spurs was 15.8 millimeters.

In addition, it was determined that of the 37 per cent of clipped spurs which blossom again in 1920, the secondary growths and leaf areas were greater than in the case of the 63 per cent of the clipped spurs which did not blossom successively. Thus the first group averaged 22.2 millimeters in length, while the second group averaged 20 millimeters. Somewhat similar data to these have been reported by Auchter (1), Roberts (17), and others.

It can thus be seen that as far as the performance of the tree is concerned, the five classes of spurs previously described should be separated. Since the continuous non-blossoming spurs do not influence the yield, at least for a period of years, they should be separated when studying spur growth relations. Likewise, the "Sec. Veg." and the "Sec. B. & F." spurs may or may not be important. Thus in certain years and under certain condition, the "Term. Veg." and "Term. B. & F." classes are the important ones to study as in Table IV.

Fruiting Condition of Tree

In our studies in Maryland, it was noted that the numbers of spurs of the five different classes found on trees depended mainly on the fruiting condition of the tree. In other words, it was important to know whether the tree was in an annual bearing condition, and if so, which type of annual bearing as outlined on page 22, or whether, if in a biennial bearing condition, the measurements were taken in the "off" year, or the "on" year.

TABLE III

Record of Same Tree in Same Year as the One Shown in Tables I and II. The Non-Blossoming Spurs have been Eliminated in this Table. Note the Changed Percentages of Spurs in the Term. Veg. and Term. B. and F. Classes of Spurs Especially in the Cases of the Shorter Lengths Compare with Percentages in Table II

Length of Spur Growth in 1920.	Vegetative and Reproductive Performance in 1921. (York Imperial).								
	Term Veg.		Term B. & F.		Sec. Veg.		Sec. B. & F.		Total Number of Spurs
Length in mm.*	Number of Spurs	Per cent	Number of Spurs	Per cent	Number of Spurs	Per cent	Number of Spurs	Per cent	
1	0	0.0	0	0.0	0	0.0	0	0.0	0
2	10	45.4	9	40.9	3	13.7	0	0.0	22
3	30	42.8	26	37.2	12	17.1	2	2.9	70
4	53	37.0	77	53.2	11	7.6	2	1.2	143
5	54	36.4	89	60.1	4	2.7	1	2.8	148
6	35	23.0	111	23.1	5	3.2	1	0.7	152
7	50	34.0	95	64.6	2	1.4	0	0.0	147
8	50	34.9	87	60.9	4	2.8	2	1.4	143
9	17	25.0	48	70.5	3	4.5	0	0.0	68
10	14	21.2	49	74.2	2	3.0	1	1.6	66
11	8	26.6	22	73.4	0	0.0	0	0.0	30
12	6	24.0	19	76.0	0	0.0	0	0.0	25
13	5	25.0	15	75.0	0	0.0	0	0.0	20
14	2	25.0	5	62.5	1	12.5	0	0.0	8
15	4	40.0	6	60.0	0	0.0	0	0.0	10
16	1	20.0	4	80.0	0	0.0	0	0.0	5
17	0	0.0	4	100.0	0	0.0	0	0.0	4
18	1	25.0	2	50.0	0	0.0	1	25.0	4
19	0	0.0	5	100.0	0	0.0	0	0.0	5
20	0	0.0	2	100.0	0	0.0	0	0.0	2
21	0	0.0	1	100.0	0	0.0	0	0.0	1
22	1	33.3	2	66.7	0	0.0	0	0.0	3
23	1	50.0	1	50.0	0	0.0	0	0.0	2
24	0	0.0	1	100.0	0	0.0	0	0.0	1
25	0	0.0	2	100.0	0	0.0	0	0.0	2
26	0	0.0	1	100.0	0	0.0	0	0.0	1
27	0	0.0	0	0.0	0	0.0	0	0.0	0
28	0	0.0	0	0.0	1	100.0	0	0.0	1
29	0	0.0	0	0.0	0	0.0	0	0.0	0

*The maximum length found in 1920 on spurs, as defined on page 138, was 28 mm.

TABLE IV

Record of Same Tree in Same Year as the One Shown in Tables I to III. The Non-Blossoming Spurs and the Spurs with Secondary Growths have been Eliminated in the First Half of this Table. Note the Effect of these Eliminations on Percentages in each Group. Compare to Tables I, II and III. In the Second Half of the Table, the Influence of Adding the Continuous Non-Blossomers to the Term. Veg. Class is Shown

Length of Spur Growth in 1920.	Vegetative and Reproductive Performances in 1921. (York Imperial).										
	Term Veg.		Term B & F		Total Number in these Classes	Length of spur growth in 1920	Continuous Non-Blossoming and Term. Veg.		Term B & F.		Total Number in these Classes
Length in mm.	Number of Spurs	Per cent	Number of Spurs	Per cent		Length in mm.	Number of Spurs	Per cent	Number of Spurs	Per cent	
1	0	0.0	0	0.0	0	1	7	100.0	0	0.0	7
2	10	52.6	9	47.4	18	2	88	90.7	9	9.3	97
3	30	53.6	26	46.4	56	3	120	82.2	26	17.8	146
4	53	40.7	77	59.3	130	4	99	56.2	77	43.8	176
5	54	37.7	89	62.3	143	5	65	42.2	89	57.8	154
6	35	23.9	111	76.1	146	6	36	24.4	111	75.6	147
7	50	35.1	95	64.9	145	7	55	36.6	95	63.4	150
8	50	37.1	87	62.9	137	8	50	37.1	87	62.9	137
9	17	26.1	48	73.9	65	9	17	26.1	48	73.9	65
10	14	22.2	49	77.8	63	10	14	22.2	49	77.8	63
11	8	26.6	22	73.4	30	11	8	26.6	22	73.4	30
12	6	24.0	19	76.0	25	12	6	24.0	19	76.0	25
13	5	25.0	15	75.0	20	13	5	25.0	15	75.0	20
14	2	28.5	5	71.5	7	14	2	28.5	5	71.5	7
15	4	50.0	6	60.0	10	15	4	40.0	6	60.0	10
16	1	20.0	4	80.0	5	16	1	20.0	4	80.0	5
17	0	0.0	4	100.0	4	17	0	0.0	4	100.0	4
18	1	33.3	2	66.7	3	18	1	33.3	2	66.7	3
19	0	0.0	5	100.0	5	19	0	0.0	5	100.0	5
20	0	0.0	2	100.0	2	20	0	0.0	2	100.0	2
21	0	0.0	1	100.0	1	21	0	0.0	1	100.0	1
22	1	33.3	2	66.7	3	22	1	33.3	2	66.7	3
23	1	50.0	1	50.0	2	23	1	50.0	1	50.0	2
24	0	0.0	1	100.0	1	24	0	0.0	1	100.0	1
25	0	0.0	2	100.0	2	25	0	0.0	2	100.0	2
26	0	0.0	1	100.0	1	26	0	0.0	1	100.0	1

It was also found that the relation between individual spur length and leaf or fruit bud formation, depended on the condition of the tree as stated above, and the year in which the data were taken.

Measurements were taken on trees of the York Imperial, Stayman Winesap, Wealthy, Grimes and Rome Beauty varieties. Due to lack of space, the complete records of York Imperial only are given in this paper, as shown in Tables I to VI.

ANNUAL BEARING YORK IMPERIAL

Measurements were made in the spring of 1921 of the 1920 growths of the spurs on two 15 year old York Imperial trees, which appeared to be in an annual bearing condition. Part of the limbs were bearing one year and part the next. On some limbs, part of the spurs bore one year and the others the next. These two conditions are explained in numbers one and five on page 143. A medium sized crop was being borne by both trees.

On one tree the results showed in 1921 that 293 spurs had not blossomed, 375 spurs had blossomed but had not set, and 228 spurs had blossomed and set. Secondary growths were not included in these numbers. Continuous non-blossomers were also excluded. The other tree (Table II) had 342 spurs which did not blossom and 683 spurs which had blossomed, about half of which set.

The average lengths in 1920 of these different groups of spurs were as follows:

	Number of Spurs	Average length in 1920 mm.	Performance in 1921
Tree No. 1	293	3.85	No blossoms
	375	4.70	Blossomed—No set
	228	5.28	Blossomed—and set
Tree No. 2 .... (Table II)	342	6.5	No blossoms
	683	7.4	Blossomed

It can be noted that although the actual lengths of the blossoming and non-blossoming spurs were different on the two trees, due to differences in general tree vigor, still those spurs which had formed blossom buds had made longer growths in the preceding year in both cases.

Measurements in 1918, of annual bearing Rome Beauty trees about 20 years old showed the non-blossoming spurs to have grown 6.4 millimeters on the average in 1917, while the blossoming spurs had averaged 8.0 millimeters. On an annual bearing Grimes tree these lengths were 6.3 millimeters and 7.13 millimeters respectively. The following year, these same length relations held with the Rome Beauty and Grimes except that all lengths were about tripled in all cases. It can thus be seen that in general the growth relations and performances of these spurs in the case of the annual bearing York Imperial (Table II), Rome Beauty and Grimes held according to the general relation outlined by Roberts (17). It should be noted, however, that there were not wide differences

between the average lengths of these different classes. Likewise, it should be noted that there were none of the over-vegetative class of spurs.

Biennial Bearing York Imperial Tree (Off Year)

The complete record for three years of one of the York Imperial trees is given in Tables I to VI. It can be seen in Table II that only a medium crop was borne in 1921, and from the large number of "Term. Veg." growths, one might assume the tree to be in an annual condition. This tree was in an annual condition in 1920 and 1921, as described previously and the general growth relations held. It can also be seen in the Table that a much higher percentage of the spurs of four millimeter lengths and above formed fruit buds. No clearly defined over-vegetative lengths were apparent. There were several "Sec. Veg" spurs, a few "Sec. B. & F." spurs and a large number of continuous non-blossomers. (Table II).

The spur growth in 1921, and performance in 1922, of the *same* tree are shown in Table V.

Apparently the number of blossoms in 1921, and the crop in 1921, exerted such an influence on this tree, that it was thrown out of bearing in 1922, and became a biennial bearer with an "off" year. It will be noted that there are practically no "Term. B. & F." spurs, also no "Sec. B. & F." spurs. The "Term. Veg." spurs of 1921 (1920 growths) did not form fruit buds for 1922 regardless of the length which they made in 1921. The continuous non-blossoming fruit spurs remained in approximately the same total numbers, but made shorter growths on the average in 1921 than in 1920.

Considering only the terminal vegetative growths in 1921, it was found that 6.1 per cent were over twelve millimeters in length, while 7.0 per cent were below four millimeters. The secondary vegetative growths in these groups were 8.2 per cent and 17.1 per cent respectively. Thus, the length of spur growths on the average was fair, although a medium crop was produced.

TABLE V

1921 Spur Growth and 1922 Performance of Same York Imperial Tree as Shown in Tables I to IV. This Tree has Changed since 1921 to a Biennial Bearing Condition and is in the "Off" Year.

Length of spur growth in 1921	Vegetative and Reproductive Performance in 1922. (York Imperial)										
	Continuous Non-Blossoming		Term. Veg.		Term B. & F.		Sec. Veg.		Sec. B. & F.		
Length in mm.*	Number of Spurs	Per cent	Number of Spurs	Per cent	Number of Spurs	Per cent	Number of Spurs	Per cent	Number of Spurs	Per cent	Total number of spurs per tree
1	20	95.2	0	0.0	0	0.0	1	4.8	0	0	21
2	90	72.0	2	1.6	0	0.0	33	26.4	0	0	125
3	85	43.6	25	12.8	0	0.0	85	43.6	0	0	195
4	30	15.6	46	24.0	1	0.5	115	60.0	0	0	192
5	5	2.6	71	36.8	1	0.5	116	60.1	0	0	193
6	1	0.6	64	39.2	0	0.0	98	60.2	0	0	163
7	0	0.0	54	44.2	0	0.0	63	51.1	0	0	117
8	0	0.0	39	43.8	0	0.0	50	56.2	0	0	89
9	0	0.0	25	47.1	0	0.0	28	52.9	0	0	53
10	0	0.0	22	50.0	0	0.0	22	50.0	0	0	44
11	0	0.0	12	42.8	0	0.0	16	57.2	0	0	28
12	0	0.0	4	23.5	0	0.0	13	76.5	0	0	17
13	0	0.0	7	36.8	0	0.0	12	63.2	0	0	19
14	0	0.0	2	16.6	0	0.0	10	83.4	0	0	12
15	0	0.0	4	33.3	0	0.0	8	66.7	0	0	12
16	0	0.0	0	0.0	0	0.0	8	100.0	0	0	8
17	0	0.0	2	33.3	0	0.0	4	66.7	0	0	6
18	0	0.0	1	33.3	0	0.0	2	66.7	0	0	3
19	0	0.0	2	40.0	0	0.0	3	60.0	0	0	5
20	0	0.0	0	0.0	0	0.0	3	100.0	0	0	3
21	0	0.0	1	100.0	0	0.0	0	0.0	0	0	1
22	0	0.0	2	100.0	0	0.0	0	0.0	0	0	2
23	0	0.0	0	0.0	0	0.0	0	0.0	0	0	0
24	0	0.0	0	0.0	0	0.0	0	0.0	0	0	0
25	0	0.0	1	50.0	0	0.0	1	50.0	0	0	2
26	0	0.0	1	100.0	0	0.0	0	0.0	0	0	1
27	0	0.0	0	0.0	0	0.0	3	100.0	0	0	3
28	0	0.0	0	0.0	0	0.0	1	100.0	0	0	1
29	0	0.0	0	0.0	0	0.0	0	0.0	0	0	0
30	0	0.0	0	0.0	0	0.0	0	0.0	0	0	0
31	0	0.0	0	0.0	0	0.0	0	0.0	0	0	0
32	0	0.0	0	0.0	0	0.0	0	0.0	0	0	0
33	0	0.0	0	0.0	0	0.0	0	0.0	0	0	0
34	0	0.0	0	0.0	0	0.0	0	0.0	0	0	0
35	0	0.0	1	33.3	0	0.0	2	66.7	0	0	3

*The maximum length found in 1921 on spurs, as defined on page 133 was 35 mm.

BIENNIAL BEARING YORK IMPERIAL TREES "ON YEAR"

The 1922 spur growth and the 1923 performance of this same York Imperial tree are given in Table VI. It can be seen that practically all of the spurs formed blossom buds in 1922. There are, of course, practically no "Sec. Veg." or "Sec. B. & F." spurs since the tree blossomed very little in 1922. It will be noted that most of the spurs on the tree blossomed in 1923. There were comparatively few "Term. Veg." spurs. It should also be noted that all except 39 of the continuous non-blossoming spurs of 1921 and 1922 (Tables II and V), blossomed in this crop year. This tree had been pruned and nitrated in 1922, and apparently this group of spurs had become invigorated so that they blossomed in 1923, with the rest of the tree.

In this connection, some other studies with continuous non-blossoming spurs, is interesting. Several trees with numerous continuous non-blossoming spurs were selected. Some were pruned and nitrated heavily in the crop year. Others were pruned and

nitrated heavily in the off year. In both cases, the continuous non-blossoming spurs were invigorated so that they made much more growth than normal. However, those treated in the crop year, which resulted in increased length being made, did not blossom in the off year even though their lengths were of the blossoming class. On the other hand, those treated in the off year, with resulting increased growth, practically all blossomed the next year with the tree.

Reference to Table VI shows that the spurs blossomed regardless of the length which they had made the previous year. It should also be noted that with this tree no over vegetative growths were obtained. They all blossomed. Of course no spurs made a growth above 55 millimeters in length, but under our usual orchard management conditions in Maryland, this over vegetative class, within the limits of our definition of a spur, has not yet been found.

A study of the 1922 growth conditions of this tree, eliminating secondary growths and continuous non-bearing spurs, shows that 27 per cent of the growths were over 12 millimeters in length and 10 per cent under four millimeters. A nearby Wealthy tree, 15 years old, showed 34.9 per cent of its spurs over 12 millimeters in length, and 2.6 per cent under four millimeters. This same tree, the year before when it was producing a crop, showed 23 per cent above 12 millimeters and 7.7 per cent of its spurs below four millimeters in length. In the off year none of the Wealthy spurs blossomed regardless of length made the previous season and in the on year, all of the spurs blossomed regardless of the length made the previous year. Thus it can be seen that in general the growth conditions were quite good with the York Imperial and Wealthy trees used.

Although there was no correlation between the length and performance of the individual spurs, when the tree was in an "off" year, or an "on" year, still it is true that the average length of the spurs was greater as a whole over the tree in an "off" year than in an "on" year. Secondary growths were not included in the measurements. The average terminal growth of the spurs, made in 1921, when the tree was bearing was 6.3 millimeters, while in 1922, without a crop, the average terminal length made by the spurs was 10.6 millimeters.

Summary of Spur Growth Relations and Condition of Tree

It can thus be seen by referring to Tables II, V, and VI, and in the discussion given of other varieties, that in spur growth studies it is very important to know whether an annual bearing variety is being studied, or a biennial bearing variety. If the tree is a biennial bearing variety it is important to know and state whether the tree is in the "off" year, or "on" year when the studies are made.

Our studies show that the spur growth and fruiting relations hold with many of the annual varieties and with many of the biennial varieties when they are in certain types of an annual

TABLE VI

1922 Spur Growth and 1923 Performance of Same York Imperial Tree as Shown in Tables I to V. This Tree is now in a Biennial Bearing Condition and is in the "On" Year.

Length of spur growth in 1922	Vegetative and Reproductive Performance in 1923. (York Imperial)										
	Continuous Non-Blossoming		Term. Veg.		Term. B. & F.		Sec. Veg.		Sec. B. & F.		
Length in mm.*	Number of Spurs	Per cent	Number of Spurs	Per cent	Number of Spurs	Per cent	Number of Spurs	Per cent	Number of Spurs	Per cent	Total number of spurs on tree
1	4	50.0	0	0.0	4	50.0	0	0.0	0	0.0	8
2	5	9.1	1	1.8	49	89.1	0	0.0	0	0.0	55
3	25	24.7	2	2.0	74	73.3	0	0.0	0	0.0	101
4	5	5.3	2	2.1	88	92.6	0	0.0	0	0.0	95
5	0	0.0	4	3.7	104	95.4	1	0.9	0	0.0	109
6	0	0.0	7	6.2	105	93.8	0	0.0	0	0.0	112
7	0	0.0	1	0.9	103	98.2	0	0.0	1	0.9	105
8	0	0.0	0	0.0	107	100.0	0	0.0	0	0.0	107
9	0	0.0	3	3.7	77	95.1	0	0.0	1	1.2	81
10	0	0.0	1	1.2	85	98.8	0	0.0	0	0.0	86
11	0	0.0	2	4.9	39	95.1	0	0.0	0	0.0	41
12	0	0.0	2	4.4	43	95.6	0	0.0	0	0.0	45
13	0	0.0	0	0.0	40	100.0	0	0.0	0	0.0	40
14	0	0.0	3	8.1	34	91.9	0	0.0	0	0.0	37
15	0	0.0	2	6.1	31	93.9	0	0.0	0	0.0	33
16	0	0.0	1	3.8	25	96.2	0	0.0	0	0.0	26
17	0	0.0	0	0.0	28	100.0	0	0.0	0	0.0	28
18	0	0.0	0	0.0	26	100.0	0	0.0	0	0.0	26
19	0	0.0	0	0.0	17	100.0	0	0.0	0	0.0	17
20	0	0.0	0	0.0	19	100.0	0	0.0	0	0.0	19
21	0	0.0	0	0.0	8	100.0	0	0.0	0	0.0	8
22	0	0.0	0	0.0	12	100.0	0	0.0	0	0.0	12
23	0	0.0	1	10.0	9	90.0	0	0.0	0	0.0	10
24	0	0.0	2	22.2	7	87.8	0	0.0	0	0.0	9
25	0	0.0	0	0.0	8	100.0	0	0.0	0	0.0	8
26	0	0.0	0	0.0	6	100.0	0	0.0	0	0.0	6
27	0	0.0	0	0.0	7	100.0	0	0.0	0	0.0	7
28	0	0.0	0	0.0	3	100.0	0	0.0	0	0.0	3
29	0	0.0	0	0.0	3	100.0	0	0.0	0	0.0	3
30	0	0.0	0	0.0	8	100.0	0	0.0	0	0.0	8
31	0	0.0	0	0.0	2	100.0	0	0.0	0	0.0	2
32	0	0.0	0	0.0	1	100.0	0	0.0	0	0.0	1
33	0	0.0	0	0.0	2	100.0	0	0.0	0	0.0	2
34	0	0.0	0	0.0	4	100.0	0	0.0	0	0.0	4
35	0	0.0	0	0.0	4	100.0	0	0.0	0	0.0	4
36	0	0.0	0	0.0	4	100.0	0	0.0	0	0.0	4
37	0	0.0	0	0.0	2	100.0	0	0.0	0	0.0	2
38	0	0.0	0	0.0	1	100.0	0	0.0	0	0.0	1
39	0	0.0	0	0.0	1	100.0	0	0.0	0	0.0	1
40	0	0.0	0	0.0	1	100.0	0	0.0	0	0.0	1
41	0	0.0	0	0.0	2	100.0	0	0.0	0	0.0	2
42	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
43	0	0.0	0	0.0	1	100.0	0	0.0	0	0.0	1
44	0	0.0	0	0.0	4	100.0	0	0.0	0	0.0	4
45	0	0.0	0	0.0	2	100.0	0	0.0	0	0.0	2
46	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
47	0	0.0	0	0.0	3	100.0	0	0.0	0	0.0	3
48	0	0.0	0	0.0	1	100.0	0	0.0	0	0.0	1
49	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
50	0	0.0	0	0.0	1	100.0	0	0.0	0	0.0	1
51	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
52	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
53	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
54	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
55	0	0.0	0	0.0	1	100.0	0	0.0	0	0.0	1

*The maximum length found in 1922 on spurs, as defined on page 133 was 55 mm.

bearing condition. It might, of course, be possible to have a tree bearing annual crops by such means as explained in numbers two and six on page 143. In such cases spur length relations might not hold even if the tree was in an annual condition.

They also show clearly that no relation between individual spur length and performance exists when the biennial tree is in an "off" year, or an "on" year, except that the blossoming spurs which set in the crop year may be those which have made the greater growth in length or diameter the previous year.

We might add that general observations made on other trees during the past several years would warrant this same conclusion. As a matter of fact, most of our middle aged biennial bearing varieties in commercial orchards in Maryland are in the biennial condition; that is, large crops are borne one year and practically nothing the next. It can thus be seen that it is rather unusual under general orchard conditions to find the individual spur length relations in the case of the biennial varieties. They are of course much easier found in the annual bearing varieties.

As stated in the beginning, we feel that we have added little if anything new to our knowledge of fruit spur growth and performance in addition to that which has already been published by Roberts (17), Hooker and Bradford (9), and others, but we do feel that it is important to emphasize certain facts more forcibly than they have been emphasized by some, in order to avoid misunderstandings by growers and some investigators, who are inclined to expect that the correlation of spur lengths and performance should hold under all conditions. We hope, that by this paper, some misunderstandings and apparent contradictions will be explained.

OTHER GENERAL GROWTH RELATIONS ON BIENNIAL TREES

Terminal Blossoming and Lateral Blossoming: Some other studies and observations on the sections of wood younger than three years of age, showed the influence of the bearing condition on the production of blossoms on this type of wood. Terminal and lateral blooming on one year wood occurred quite commonly and heavily in the crop year, but was rather scarce, if any, in the off year with biennial trees. Therefore, a study of the bearing habits as regards terminal and lateral blossoming of a biennial bearing variety, should take account of the year in which the tree is studied, and the condition of bearing of the tree. A light crop, if any, in the off year would thus be largely on spurs.

Blossoming on Two Year Wood: The production of blossoms on spurs on two year wood under the average growth conditions of Maryland also depended upon the bearing condition of the tree. A high percentage of the two year wood bore blossoms in the crop year and practically no blossoms in the off-year, regardless of the length of terminal growth which it had made in each year, although these growths did not reach an over vegetative length.

The above statements on terminal, lateral and two year wood blossoming, apply to our average conditions of growth on bien-

nial York Imperial trees in Maryland. It should be stated, however, that a greater length of terminal growth might be produced on such trees which might not blossom terminally or laterally in the crop year, and might, therefore, produce spurs that would blossom on the two year wood the next year. This possibility has been suggested by Roberts (17) as an important means of producing annual bearing.

THE CONDITION OF ANNUAL BEARING WITH BIENNIAL BEARING VARIETIES

It is possible for a tree to bear fair crops of fruit each year, or at least a medium crop one year and a light one the next. In producing these so called annual crops the tree might be bearing in any one of several ways. Thus (1) it is possible for certain limbs to be bearing one year and other limbs the next. This might be opposite sides of the tree in one case, or top limbs bearing one year and bottom limbs the next. In other cases, the bearing limbs might be scattered uniformly over the tree. This type of annual bearing often occurs regardless of individual spur lengths on the bearing, or non-bearing limbs. It is generally true, of course, that any non-bearing, as well as bearing spurs, on the bearing limbs, make shorter growth lengths during the same year than those spurs on the non-bearing limbs. (2) Some trees might bear more or less regularly on laterals and terminals on one year wood. (3) It has been suggested that some trees may bear on older spurs in the older parts of the tree in the so-called "off" year. (4) Alternate small branches on the large main branches may be bearing in different years. (5) In some cases spur growth conditions may be so varied over a tree that a medium crop is borne by different spurs on the same limbs each year. (6) The regular bearing on spurs of two year wood may be the cause of annual bearing in many cases. (7) The tree may be in such a state of general vigor and growth, due to excellent fertilizer, pruning, spraying and soil treatments, that annual crops are produced through a combination of the various methods of bearing explained above.

Of course the orchardist is interested in a fair crop each year and does not particularly care where the fruit is borne upon the tree, just so this condition of bearing is maintained. The possibility of producing annual bearing by causing any one, or a combination of certain of these desirable conditions, by subjecting the trees to certain treatments, must of course be considered by the investigator who is attempting to bring about this desirable condition in biennial trees.

INVESTIGATIONS IN AN ATTEMPT TO INFLUENCE BIENNIAL BEARING

Some cooperative work has been in progress since 1920, between the Wisconsin and Maryland Stations to determine whether the biennial bearing habit of York Imperial trees can be changed by various pruning, soil management and fertilizer treatments. Seven hundred middle-aged bearing trees are included in these tests. Whether the change to an annual condition (if this is accomplished) will mean an upset, mainly of spur growth

relations throughout the tree, or of general growth conditions over the whole tree is one of the things being studied.

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Factors that Influence the Effectiveness of Peach Thinning

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THERE is comparatively little published data available relative to the thinning of peaches. Thinning of the fruit when the trees are heavily loaded is generally recommended, but not practiced as extensively as it should be by fruit growers in some peach growing sections. It is generally recognized that thinning properly executed, is a profitable and economical commercial practice. On the other hand, fruit growers frequently make the statement that thinning as practiced in their orchards does not produce the expected and desired results. Furthermore, requests are frequently made by fruit growers, extension workers, students and others interested directly or indirectly in the production or marketing of peaches, for definite information based on experimental data relative to the proper time to thin, the amount of fruit to remove, and the results to be expected, with particular reference to actual increases in size of fruit, effect upon the number of baskets per tree, or per acre, and the gain in net returns from the sale of the fruit.

OUTLINE OF EXPERIMENT

Numerous experiments have been conducted to secure information on these points, but all of those on which results have been published have been on a rather limited scale, and involved a small number of trees. In view of the conditions described an attempt was made during the past season to secure some data based on the thinning of comparatively large numbers of trees. An experiment was outlined and carried through the season involving two varieties; namely, Carman and Belle, approximately 300 trees of each variety producing over 1800 bushels of fruit. The experiment was conducted in the Seabrook Orchards, at Bridgeton, in Cumberland County, New Jersey. Young, vigorous trees making their fourth summer's growth, with an average spread of 16 feet were used in the thinning treatments. Six thinning treatments in addition to a check were carried through on each variety. Each treatment involved from 45 to 50 trees of a variety, while 16 Carman and 15 Belle trees were left unthinned as checks. The chief factors studied in this experiment were two; first, the effect of degree of thinning, and, second, the effect of time of thinning.

The thinning treatments on each variety may be designated as follows:

1—Early—Light	4—Early—Heavy
2—Medium—Light	5—Medium—Heavy
3—Late—Light	6—Late—Heavy

TIME AND DEGREE OF THINNING

The early thinning was on June 7 and 8, while the pits were still soft and watery. The medium early thinning was just 2

TABLE I

Average Gain in Size of Fruit in Terms of Greatest Transverse Diameter

BELLE

Treatment Inches	June 8 to June 22	June 22 to July 6	July 6 to July 19	July 19 to Aug. 3	Aug. 3 to Aug. 17	Total for 10 weeks	Average Aug. 17
4 to 6 June 8	.12	.06	.07	.19	.51	0.95	2.19
4 to 6 June 22	.11	.05	.07	.16	.49	0.88	2.11
4 to 6 July 5	.11	.03	.08	.16	.52	0.90	2.13
6 to 8 June 8	.21	.07	.04	.23	.48	1.03	2.26
6 to 8 June 22	.11	.08	.09	.21	.43	0.92	2.15
6 to 8 July 5	.11	.03	.14	.20	.52	1.00	2.23
Check	.11	.03	.06	.15	.31	0.66	1.89

CARMAN

						Total for 8 weeks	Average Size August 3
4 to 6 June 7	.15	.06	.18	.36	...	.75	1.93
4 to 6 June 21	.11	.06	.16	.40	...	.73	1.91
4 to 6 July 5	.11	.03	.18	.34	...	.66	1.84
6 to 8 June 7	.23	.09	.18	.44	...	.94	2.12
6 to 8 June 21	.11	.10	.19	.43	...	.83	2.01
6 to 8 July 5	.11	.03	.26	.40	...	.80	1.98
Check	.11	.03	.18	.22	...	.54	1.72

weeks later on June 21 and 22, at which time the pits were hard and the kernels still soft. The late thinning was on July 5, when the average transverse diameter of Carman was 1.32 and of Belle 1.37 inches. The light thinning consisted of removing the green fruits so that those left on the tree were spaced from 4 to 6 inches along the branches, while after the heavy thinning the fruits were spaced 6 to 8 inches.

Amount of Fruit Set and Number Removed

The average number of fruits removed from each Carman tree by the 4 to 6 inch thinning was 787 or 36.56 per cent, while the average number of fruits removed by the 6 to 8 inch thinning was 1012 or 52.64 per cent. The average number of fruits removed from each Belle tree by the 4 to 6 inch thinning was 505, or 40.89 per cent, and the average number of fruits removed by the 6 to 8 inch thinning was 796, or 55.54 per cent. The average number of fruits that set on the Carman trees was 1921, and on the Belle 1330, a difference of 591, or approximately 600 fruits.

The average size of the fruit on each thinning date, and at two week intervals until it was picked, was determined in terms of greatest transverse diameter. The average size of Carman on June 7, the first thinning date, was 1.18 inches, and the average size of Belle at the same time was 1.23 inches, a difference of .05 inches. Table 1 shows the average gain in size of fruit during two week intervals, from the date of the first thinning until the fruit was picked as well as the average size of the fruit on the date of the first picking.

The figures in Table 1 agree with the observations frequently made by investigators and fuit growers relative to the slow growth of the peach during the period when the pits are hardening. During the past season in this particular orchard, the pits began to harden between June 15 and 20, being quite hard on June 22, the date of the second or medium early thinning. It will be noted that the fruit of both varieties grew very slowly during the two week period beginning June 22. In this connection it is of interest to note that the Belle fruits also grew slowly during the two week period beginning July 6, the total gain from June 22 to July 19, being less than the gain from July 19 to August 3, the former a four week period and the latter a two week period. Although the development and hardening of the pits has a direct affect upon the growth of the fruit, their relation to the time of thinning is not so apparent. While it is true that early thinning resulted in larger fruit than late thinning of the same degree, it is also true that late, heavy thinning increased size more than early light thinning. In other words, these figures indicate that degree of thinning, or the percentage of fruit removed, is fully as important as the time of thinning, particularly in-so-far as the time relates to the period during which the pits are hardening. Therefore, while it is undoubtedly desirable to recommend early thinning, the time should not necessarily be determined by the condition of the pits, since with the mid-season varieties at least there is apparently quite a period of time during which peaches may be

thinned with equally effective results. Furthermore, all recommendations should be accompanied by rather specific directions regarding the degree of thinning, or in other words, the amount or percentage of fruit to be removed.

Difference in Set of Fruit

It has already been noted that the set of Belle on the trees included in this experiment was considerably lighter than the set of Carman. In this connection it is of interest to note that the trees of both varieties were of the same age and practically of the same size, thereby making each capable of maturing the same number of fruits. As a matter of fact, however, in this experiment the average unthinned Carman tree matured 1870 fruits, while the average unthinned Belle tree matured only 1264 fruits, a difference of 606 fruits per tree. This difference in set was not due to any appreciable difference in number of fruit buds, or amount of bloom, but was the result of a heavier June drop from the Belle trees. The effect of this drop on the amount of fruit removed on the various thinning dates is shown in Table II. That is, the amount of fruit removed by thinning on the various dates decreased as the season advanced because of the continuous drop of Belle fruits during June. The effect of this drop is also seen in the total yield, the difference being particularly great between the early and medium early thinnings of the same degree. Under such conditions, early thinning may be very undesirable, because of the danger of reducing the yield to a point that will entirely eliminate any advantage gained in size of fruit. Table II also shows that the average total set of fruit was very uniform on both varieties, this being particularly true of Carman where the greatest variation was less than 250 fruits. This condition indicates exceptional uniformity in pruning, fertilizing and other cultural practices.

Method of Recording Average Set Per Tree

At least five typical trees of each variety in each thinning treatment were selected as count trees. The actual number of fruits removed by thinning, and the number of fruits harvested from each count tree was recorded, and the resulting figures used to compute the average number of fruits per tree removed by thinning, the average number of fruits per tree harvested, and the average total set per tree.

Method of Recording Relative Size and Yield

The total amount of fruit harvested from the trees in each thinning treatment was recorded at each picking and each lot graded separately into four sizes by running the fruit over a Burke grader. The effect of the thinning treatments on the size of the fruit, and the comparative yield per acre are shown in Table II.

TABLE II

Effect of Thinning Treatments on Size of Fruit and Yield Per Acre

CARMAN

Treatment, Inches	Average total set per tree	Average fruits per tree removed by thinning	Average fruits per tree harvested	Bushels per acre of different grades: 1⅞ or less	1⅞ to 2⅛	2⅛ to 2⅜	2⅜ and up	Total bushels per acre
4 to 6 June 7	1821	584	1236	23	164	135	26	348
4 to 6 June 21	2078	891	1152	31	197	117	7	352
4 to 6 July 5	1907	748	1164	29	179	104	9	321
6 to 8 June 7	1741	937	803	8	97	181	35	321
6 to 8 June 21	2041	1063	977	9	173	158	13	353
6 to 8 July 5	1896	984	912	19	175	109	6	309
Check	1870	....	1870	217	259	18	..	494

BELLE

Inches				1¾ or less	1¾ to 2¼	2¼ to 2¾	2¾ and up	
4 to 6 June 8	1427	659	768	2	16	77	141	236
4 to 6 June 22	1320	491	829	2	40	185	120	347
4 to 6 July 5	991	367	624	2	34	131	88	255
6 to 8 June 8	1476	913	563	1	10	50	115	176
6 to 8 June 22	1502	771	731	3	58	137	79	277
6 to 8 July 5	1334	714	620	2	26	128	98	254
Check	1264	...	1264	68	228	127	12	435

It should be stated in this connection that the average size of all the fruits, particularly Carman, was below normal, because of the extremely dry weather that prevailed during a large part of the growing season.

One of the most striking features in connection with the data on Carman is the uniformity of yield between the various thinning treatments. The average yield per tree following the 6 to 8 inch thinning treatments was only four quarts less than the average yield per tree following the 4 to 6 inch thinning, while the average yield from all of the thinned trees was slightly over a bushel less than the average yield of the unthinned. There is considerably more variation in yield between the thinning treatments on Belle. The heavy thinning, particularly the early heavy thinning, reducing the yield to a rather marked degree. This was undoubtedly at least partly due to the drop that followed the first thinning, and continued to some extent for several weeks, thus resulting in a smaller number of fruits at maturity than would normally follow a 6 to 8 inch thinning. There are several points in connection with the dates on Belle that cannot be explained such as the high yield on the 4 to 6 inch thinning June 22, and the light set on the trees thinned 4 to 6 inches July 5. The most plausible explanation for the high yield in the first case mentioned, is that some of the trees in this particular row were about the average in size and vigor, while in the row showing a light set the opposite condition existed.

Heavy Thinning Reduces Amount of Small Fruit

The figures in Table II agree with the general observation that heavy thinning decreases the amount of small fruit, and increases the amount of large fruit. Furthermore, early thinning increased size to a greater extent than later thinning of the same degree. The unthinned trees show a high number of small fruits, although in the case of Belle this is offset to a large degree by the increased yield, and the large amount of fruit of medium size.

Effect of Thinning Treatments on Returns Per Acre

Treatments	*Carman*	*Belle*
4 to 6 inches June 7 and 8	$172.00	$351.50
4 to 6 inches June 21 and 22	171.00	461.75
4 to 6 inches July 5	138.40	335.25
6 to 8 inches June 7 and 8	191.60	269.00
6 to 8 inches June 21 and 22	176.40	339.25
6 to 8 inches July 5	136.70	345.00
Check	112.00	309.75

Above amounts based on following price per bushel at packing house

Variety	Grades			
	1	*3*	*3*	*4*
Carman	.10	.30	.70	1.00
Belle	.25	.50	1.25	1.75

The average cost of thinning in this orchard varied from $8.00 to $10.00 per acre depending upon the man, and the time of day. This cost is based upon the average man at $3.00 per day thinning from 3 to 4 trees per hour.

With Carman, early heavy thinning gave the highest return followed by medium heavy, light early, and light medium. Late thinning on the other hand gave relatively low returns regardless of the degree of thinning. Furthermore, the returns from the unthinned trees compare favorably with the returns from some of the thinning treatments particularly with Belle where the value of the fruit from the check is actually higher than the early heavy thinning, because of the great difference in yield.

SUMMARY

1. Two degrees of thinning; namely, 4 to 6 inches and 6 to 8 inches both increased the size of the fruit over unthinned trees.

2. The degree of thinning or percentage of fruits removed was fully as important as the time of thinning.

3. The statement commonly made to the effect that peaches should be thinned before the pits harden to secure satisfactory results, was not substantiated in this experiment.

4. Early thinning was particularly effective with Carman, a comparatively early ripening variety.

5. There is evidently a relatively long period during which each variety, particularly those ripening with Belle or later, may be thinned with equal effectiveness.

6. Heavy thinning increased the number of large fruits without materially decreasing the yield with one exception, in the case of Belle where early heavy thinning combined with an abnormal drop made a decided reduction in yield.

7. This experiment indicates a direct relation between degree of thinning and size of fruit.

8. The degree of thinning may be carried to such an extreme that the advantage gained in size of fruit will be lost by a decrease in yield.

9. The results of this experiment indicate the importance of considering varietal and individual orchard conditions in making thinning recommendations.

10. The thinning of peaches although a simple operation in itself, involves many details and factors that deserve careful consideration by fruit growers as well as investigators.

Observations on the Rest Period of Deciduous Fruit Trees in a Mild Climate

By FRANK R. HODGSON, *University of California, Berkeley, Calif.*

MOST investigations on the rest period of plants have been carried out in regions of severe winter climates. The present study was carried out in the mild climate of central California.

Time of Natural Ending of the Rest Period

Collections of cuttings of 300 varieties of eight species were made at intervals throughout the late fall and winter. They were collected at Niles where the climatic conditions are mild with a comparatively humid atmosphere and temperatures rarely reaching 0°C., or 38°C. All cuttings consisted of strong, healthy, terminal growth of one year old shoots approximately 8 to 10 inches long. For the sake of uniformity the material was collected from all parts of the tree. The cuttings were placed in the greenhouse for growth. If they failed to start growth within two weeks they were judged to be in a sound resting state.

Table I

The Normal Ending of the Rest Period of the Leaf and Flower Buds of Deciduous Fruit Trees

Species	Number of Varieties	Date of First Cuttings	Date the Rest-period is Over
Apricots	14	Nov. 13, 1922	Jan. 1, 1923
Apples	11	Jan. 1, 1923	Feb. 14, 1923
Apples	69	Jan. 1, 1923	Mar. 1, 1923
Almonds	13	Nov. 20, 1922	Nov. 20, 1922
Almond hybrid seedlings	44	Nov. 20, 1922	Nov. 20, 1922
Cherries	11	Dec. 20, 1922	Jan. 26, 1923
Cherries	19	Dec 20, 1922	Feb. 10, 1923
Peaches	14	Nov. 20, 1922	Jan. 9, 1923
Peaches	22	Nov. 20, 1922	Jan. 26, 1923
Pears	6	Dec 20, 1922	Jan. 20, 1923
Pears	18	Dec. 20, 1922	Jan. 26, 1923
Pears	18	Dec. 20, 1922	Feb. 10, 1923
Plums (Japanese)	8	Dec. 20, 1922	Dec. 20, 1922
Plums (Japanese)	11	Dec. 20, 1922	Jan. 26, 1923
Plums (European)	30	Nov. 20, 1922	Feb. 14, 1923
Plums (European)	6	Nov. 20, 1922	Jan. 26, 1923

Nearly every species studied contains a few varieties which do not appear to have a rest period co-extensive with the majority of varieties of that species. Japanese plumes end their rest period considerably before European varieties. Almonds appear to have a very short and feeble rest period if they may be said to have any at all. Thirteen commercial varieties and 44 hybrids exhibited no rest period when collected on November 20, or later. If a rest period occurs it must be before the middle of November. Likewise eight varieties of Japanese plums have their rest period occur before the middle of December.

A gradual emergence from the rest period is shown in most species. In mid-winter nearly all varieties are in a deep resting state, whereas, a little later, a few varieties grow readily, and a few days still later more varieties push out. This is especially true of those varieties that end their rest period in mid-winter. Apples which end their rest period very late, show a rather sudden ending which occurs about March first. At this date many species and varieties which end their rest period earlier are in active growth and some in full bloom.

Rest Period and Leaf Fall

There appears to be no relation between the presence or absence of leaves on the trees and the rest period. In the above experiments all collections of material made during November had from one-half to two-thirds of the leaves still attached and apparently functioning. The results of the experiments showed that the almond varieties were not in a resting state, while all other species were in a profound resting condition.

Inception of the Rest Period

Comparatively little is known regarding the time of inception of the rest period. Some investigators apparently believe that it begins with the fall of the leaves, others that it starts soon after the formation of the terminal buds. It may possibly begin with the maturation of the bud. The evidence obtained from studies of the rest-period of seeds and bulbs by Howard (1) and Wiggans (4) indicates that this may well be the case with flower and leaf buds. Howard (1) showed that bulbs enter the rest-period immediately after flowering, which usually occurs in the spring or summer. These bulbs remain in a resting condition throughout the remainder of the season while they still have green leaves above ground. As severe weather comes they enter the winter dormant period and remain so until it ends when they will grow readily. In the meantime, the resting condition ceases sometimes during the dormant stage. In other words, bulbs enter a resting condition just after the new bulbs are formed and remain in this condition in spite of favorable conditions until the dormant season comes in summer or autumn. Howard (2) and Wiggans (4) showed that seeds enter a resting state upon maturation and require a period of rest before they will grow successfully.

Fruit buds begin to develop in June, or early in July, and reach their greatest growth during August and September, and like seeds and bulbs, remain in a dormant condition during late summer and fall and resume growth normally the following spring. Their rest-period apparently extends like that of bulbs and seeds from the time of maturity of the buds until sometime after dormancy begins.

Certain buds, however, develop into lateral branches on many trees in the same season that they are formed. On the other hand, many buds, especially those toward the base of the branch remain inactive during the following and later years. Those buds are commonly referred to as dormant buds. It seems possible that they remain in the resting condition from which they may be aroused by nearby injuries, such as inflicted in pruning operations, or they may become active spontaneously. These phenomena occur apparently without direct reference to the presence or absence of leaves.

Occasionally in this, and in other regions, when late warm autumns occur, buds start growth while the leaves are still on the trees. In such cases it seems quite probable that the external

conditions of temperature and moisture hasten the breaking of the rest-period, resulting in the growth of buds.

The Relation of Starch Hydrolysis to the Ending of the Rest-Period

In the course of some experiments where ether fumes were employed in breaking the rest-period of peaches, it was noticed that in many cases the buds swelled, then were abscissed at the point of attachment to the twig, and a callus-like layer was formed. On examination of the nodal regions of such twigs and the tissue at the point of attachment of the buds, it was found that the starch had completely disappeared in this region. In untreated twigs in which no abscission of buds occurred and which were placed in the greenhouse at the same time as the treated twigs, abundant starch was found. The idea suggested itself that the ether treatment might have brought about the rapid hydrolysis of the starch. Abscission of the buds which followed may have some relation to the hydrolysis of the starch. The rapid disappearance of the starch could only be brought about by an initiation, or stimulation, of diastatic activity. Howard (3), Stuart (5), Bonns (6) and Coville (7) have suggested that the effect of etherization in breaking the rest-period is due to a stimulation of enzyme activity. Howard (3) offers some data to support this, working with ground tissue removed from the twig. Apparently no attempt has been made to follow the effects of etherization in the intact bud and twig.

After etherization of buds in the rest-period they showed evident growth in one to two weeks usually, when placed in the greenhouse. Growth was probably occurring before this time but was not externally evident. Under greenhouse conditions the starch nearly all disappeared from the bud during this period. Since growth was possible under these conditions. it cannot be said whether the dissolution of starch precedes the initiation of growth, or follows it. The starting of growth may have resulted in the rapid hydrolysis of the starch, or the reverse may have been true. If the effects of etherization could be followed in the tissues under conditions which preclude growth, or make it very unlikely to occur, some suggestion as to how etherization acts in breaking the rest-period of buds might be obtained.

Attempts to determine this point were made as follows: collections of cuttings from trees still in the rest-period were made of pears, peaches and cherries, and each lot was divided into several portions. One portion of each species was placed with the cut ends in water in the greenhouse and another in the 5°C. cold room without treatment. The remaining portions were etherized for definite periods of time, and one portion of each then placed, with the cut ends of the twigs in water in the greenhouse, and the remainder of each portion placed likewise in water in the 5°C. storage room. At the time of removal from ether and at intervals afterward, twigs were removed from each lot and freehand sections made of the buds and microchemical tests made for starch with iodine. The untreated buds in both the greenhouse and cold storage room showed no loss of starch at the end of 14 days,

whereas, all those treated showed a marked decrease in starch content at the same time, under both these conditions. The starch disappearance started in the distal region of the treated buds and gradually progressed toward the base. The starch disappearance was not complete, traces remaining throughout the bud tissue in most cases, even though growth may have taken place. The decrease of starch seemed to be in direct proportion to the severity of the treatment applied. In all cases of abscissed buds no starch was found present in the bud, or in the region immediately around the point of attachment.

The fact that these etherized cuttings, in the cold room were growth probably did not take place, lost the starch in their buds almost as rapidly as the buds of cuttings in the greenhouse under conditions where growth did take place, seems to support the idea that the breaking of the rest-period may be the result of stimulated enzyme action. How this stimulation in intact tissues by ether is produced, is uncertain. It is well known that ether causes an increase in the permeability and in the respiration rate of certain tissues, and that the latter is very high in growing buds. This may have some bearing on the question. No attempt was made to ascertain the possible effect of ether treatment on the activities of other enzymes than diastase, or to follow its effect upon the respiration rate of the buds.

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Effect of Certain Sodium and Potassium Salts on Sweet Potato Production in Eastern Virginia

By T. C. Johnson, H. H. Zimmerley, *Truck Experiment Station, Norfolk, Va.*, and F. W. Geise, *University of Maryland, College Park, Md.*

IT has been the practice for a number of years for the farmers, in limited sections of the sweet potato growing areas of Virginia, to apply sodium chloride as a top dresser in connection with the

production of sweet potatoes. Some have claimed that they have obtained good results while others are equally of the opinion that no increased yields were obtained from the use of this salt. In order to secure some definite information on the practice, the Virginia Truck Experiment Station instituted a series of experiments in 1920, the original object of which was to determine the effect of common salt (sodium chloride) on both the early and late yields of sweet potatoes. In 1921, the work was extended to include a study of the effects of sodium and potassium chloride and sodium and potassium sulphate, when used in connection with the regular fertilizers.

The first part of the experiment was conducted at the Sub-Station at Onley, Virginia, in 1920, 1921, and 1922, on the Norfolk sandy loam type of soil, and at the main Station at Norfolk in 1922 on the Norfolk loam type of soil. The location of the plats was shifted from season to season to coincide with the crop rotation system practiced.

The plats used in this test were one-tenth acre in area. Before the sweet potato plants were transferred from the beds to the field, all plats were given an application of 1000 pounds per acre of commercial fertilizer analyzing 5 per cent ammonia, 8 per cent phosphoric acid, and 7 per cent potash. This fertilizer was distributed in strips 18 inches wide and thoroughly worked into the ground before the sweet potato plants were set. The fertilizer was prepared by mixing the following ingredients:

108 pounds nitrate of soda
126 pounds sulphate of ammonia
286 pounds dry ground fish, 10 per cent ammonia
200 pounds animal tankage, 10 per cent ammonia
1000 pounds acid phosphate, 16 per cent phosphoric acid
280 pounds muriate of potash, 50 per cent potash

A high yielding strain of Little Stem or Yellow Jersey sweet potatoes was used throughout the experiments. As soon as the plants were well rooted the sodium chloride was applied broadcast between the rows in plats 1, 3, 4 and 5, and worked into the soil with a cultivator. Care was observed not to allow the salt to come into direct contact with the leaves or roots of the plants. The arrangement of the plats and treatment is shown in Table 1.

In Virginia it is customary to sell most of the potatoes immediately from the field. The harvest period extends from early August to late October. In order to determine the effects on yields at the various times of harvest, the plats were divided into two sections. One was harvested in the early part of the period and the other later in the season when the growth was practically completed.

Table I is arranged to show the treatment given the various plats and the absolute and relative yields of the potatoes obtained at both the early and late harvests. It will be noted that plats 2 and 6 were used as checks on which commercial fertilizer alone was used. On plats 1, 3, 4, and 5, the same amount of commercial fertilizer was used and plat 1 received, in addition to the fertilizer,

TABLE I

Sweet Potato Yields at Onley in 1920, 1921, 1922, and at Norfolk in 1922

Plat	Treatment—Onley	September 2, 1920 Early Harvest Marketable Potatoes Bushels Per Acre	Percentage Based on Non-salted Plats	September 27, 1920 Late Harvest Marketable Potatoes Bushels Per Acre	Percentage Based on Non-salted Plats
1	Complete fertilizer + 2000 pounds sodium chloride per acre........	273.4	117.3	296.0	101.1
2+6	Check—complete fertilizer and no sodium chloride...............	233.1	100.0	292.9	100.0
3	Complete fertilizer + 1500 pounds sodium chloride per acre........	264.0	113.3	337.4	115.2
4	Complete fertilizer + 1000 pounds sodium chloride per acre.......	273.2	117.2	327.6	111.7
5	Complete fertilizer + 500 pounds sodium chloride per acre........	257.8	110.5	268.5	98.5
Plat	Treatment—Onley	September 21, 1921		October 20, 1921	
1	Complete fertilizer + 2000 pounds sodium chloride per acre.......	274.3	141.3	312.3	130.4
2+6	Check—complete fertilizer and no sodium chloride...............	194.1	100.0	239.6	100.0
3	Complete fertilizer + 1500 pounds sodium chloride per acre........	273.9	141.1	241.1	100.6
4	Complete fertilizer + 1000 pounds sodium chloride per acre........	278 2	143.3	321.7	134.2
5	Complete fertilizer + 500 pounds sodium chloride per acre........	203.5	104.8	250.8	104.7
Plat	Treatment—Onley	September 19, 1922		October 19, 1922	
1	Complete fertilizer + 2000 pounds sodium chloride per acre........	321.4	151.0	365.0	165.6
2+6	Check—complete fertilizer and no sodium chloride...............	212.8	100.0	220.4	100.0
3	Complete fertilizer + 1500 pounds sodium chloride per acre........	267.8	125.8	281.4	127.7
4	Complete fertilizer + 1000 pounds sodium chloride per acre........	277.4	130.3	305.1	138.4
5	Complete fertilizer + 500 pounds sodium chloride per acre........	276.1	129.7	248.3	112.6
Plat	Treatment—Norfolk	September 28, 1922		October 21, 1922	
1	Complete fertilizer + 2000 pounds sodium chloride per acre........	350.0	121.7	360.0	114.8
2+6	Check—complete fertilizer and no sodium chloride...............	287.5	100.0	313.6	100.0
3	Complete fertilizer + 1500 pounds sodium chloride per acre........	337.5	117.3	357.0	113.8
4	Complete fertilizer + 1000 pounds sodium chloride per acre........	371.3	128.5	398.2	126.9
5	Complete fertilizer + 500 pounds sodium chloride per acre........	342.8	118.5	389.2	124.1

2000 pounds, plat 3, 1500 pounds; plat 4, 1000 pounds; and plat 5, 500 pounds of sodium chloride per acre. The percentage yields of all the plats are expressed relatively to the yield of the check plat which is given as a basis of 100.

At the early harvest the increase resulting from the application of 500 pounds of salt per acre ranged from 4.8 per cent in 1920, to 29.7 per cent in 1922. The 1000 pound application gave increases varying from 17.2 per cent in 1920 to 30.3 per cent in 1922, the 1500 pound application gave increases varying from 13.3 per cent in 1920 to 41.1 per cent in 1921, and the 2000 pound application gave increases varying from 17.3 per cent in 1920 to 51 per cent in 1922, over the plats receiving no salt. At the late harvest the 500 pound, the 1000 pound, the 1500 pound, and the 2000 pound applications gave increases of -1.5 per cent in 1920 to 24.1 per cent in 1922; 11.7 per cent in 1920 to 38.4 per cent in 1922; .6 per cent in 1921 to 27.7 per cent in 1922, and 1.1 per cent in 1920 to 65.6 per cent in 1922 respectively.

The average yields are summarized in Table II. It will be seen that at the late harvest the application of 1000 pounds of salt gave the greatest average increase and practically as large an increase at the early harvest as did any other quantity applied, which would seem to indicate that that amount of salt was the optimum under the conditions. By referring to the comparative yields, it will be noted that the greatest percentage of increase was obtained at the early harvest. In other words the application of sodium chloride seemed to have influenced the early development of the sweet potato.

The second part of the investigation was conducted at the Sub-Station at Onley, Virginia, in the years 1921 and 1922, on a Norfolk sandy loam soil, and at the Main Station at Norfolk, Virginia, in 1922, on a Norfolk loam soil. At the Sub-Station the work was done both years on the same area in order to receive the benefit of the residual effect of the material previously applied.

The plats, except those on which a potassium salt was used as a top dresser, were treated at the rate of 1000 pounds per acre with a complete fertilizer analyzing 5 per cent ammonia, 8 per cent phosphoric acid, and 7 per cent potash, and compounded as follows:

450 pounds animal tankage, analyzing 11 per cent ammonia
200 pounds ammonium sulphate
1000 pounds acid phosphate, containing 16 per cent phosphoric acid.
280 pounds potassium sulphate carrying 50 per cent potash
66 pounds inert filler

On the plats on which a potassium salt was used as a top dresser, fertilizer analyzing 5 per cent ammonia, 8 per cent phosphoric acid, and containing no potash, was applied so as to supply the equivalent units of nitrogen and phosphoric acid used on the other plats. This was made according to the same formula except that the potassium sulphate was replaced with an equal amount of inert filler. Both the sodium and potassium salts were of a commercial

TABLE II

Average of Yields at Onley in 1920, 1921, 1922, and at Norfolk in 1922

Plat	Treatment	Early Harvest: Marketable Potatoes Bushels Per Acre	Early Harvest: Percentage Based on Non-salted Plats	Late Harvest: Marketable Potatoes Bushels Per-Acre	Late Harvest: Percentage Based on Non-salted Plats
1	Complete fertilizer + 2000 pounds sodium chloride per acre........	304.8	131.5	333.3	125.0
2+6	Check—complete fertilizer and no sodium chloride...............	231.9	100.0	266.6	100.0
3	Complete fertilizer + 1500 pounds sodium chloride per acre........	285.8	123.2	304.2	111.1
4	Complete fertilizer + 1000 pounds sodium chloride per acre........	300.0	129.4	338.2	126.8
5	Complete fertilizer + 500 pounds sodium chloride per acre........	270.1	116.4	294.2	110.4

grade. The potassium sulphate and potassium chloride contained 50 per cent potash, while the sodium sulphate and sodium chloride were a standard 98 per cent purity.

By a study of the fertilizer and top dresser treatments as indicated in Table III, it will be seen that the experiment will permit an interpretation of the resultant yields as they may be related to the different elements contained in the various salts used as a top dresser.

TABLE III

Plat	Fertilizer Analyses	Top Dresser Pounds per 1/10 Acre Plat	Approximate Ion-equivalent	
1	5-8-7	.. None		
2	5-8-7	..100 sodium chloride	40 sodium	60 chloride
3	5-8-0	..128 potassium chloride	67 potassium	60 chloride
4	5-8-7	..122 sodium sulphate	40 sodium	82 sulphate
5	5-8-0	..149 potassium sulphate	67 potassium	82 sulphate

Plat 1, which is referred to as the check, received 1000 pounds per acre of commercial fertilizer analyzing 5 per cent ammonia, 8 per cent phosphoric acid, and 7 per cent potash. Plat 2 received, in addition to the fertilizer just mentioned, 1000 pounds per acre of sodium chloride as a top dresser, and plat 3 received 1000 pounds per acre of a fertilizer analyzing 5 per cent ammonia, 8 per cent phosphoric acid, and sufficient potassium chloride to furnish the same amount of chlorin as was furnished by sodium chloride in plat 2 and an equivalent amount of potassium as that applied to plat 5. Plats 2 and 3 were treated with equal amounts of chloride, and plat 4 was top dressed with sodium sulphate in an amount to furnish a sodium equivalent to the sodium chloride in plat 2. In plat 5 potassium sulphate used as a top dresser furnished the potassium equivalent to that used on plat 3 and sulphate equivalent to that used on plat 4. The plats were arranged in duplicate and the field divided into two parts prior to the first harvest. One-half of each of the plats was dug during the early part of the harvest season for the early yield, and the remainder was dug for the late yield. The yields were recorded in bushels of marketable sweet potatoes per acre.

The results as indicated by Table IV show that for both early and late harvests the yields of the top dressed plats exceed those in which no top dresser was used. This is significant in that it brings out the fact that the salts used in this experiment have a beneficial effect from the standpoint of production. Since the relative increase in yield due to a given salt for the different seasons and places is not consistently large, and varies to a degree comparable to the variations in the relative yield of the different treated plats, it is evident that no one salt is in any way superior to the others with respect to its ability to consistently increase the yield of potatoes above that of the other salts used.

From the standpoint of the yield with reference to the influence of the separate elements that go to make up the salts used as top dressers, there seems to be no consistent response as to in-

TABLE IV

Yield of Marketable Sweet Potatoes from Plats Treated with different Sodium and Potassium Salts as Top Dressers for the Seasons of 1921 and 1922 at Onley and for 1922 at Norfolk. Average Yield Per Acre from Duplicate Plats of 1/20 Acre Each.

Treatment of 1000 pounds per Acre of Fertilizer. Top Dresser based on 1000 pounds NaCl	Early Harvest: Bushels Marketable Potatoes Per Acre	Early Harvest: Percentage Based on Non-Top Dressed Plats	Late Harvest: Bushels Marketable Potatoes Per Acre	Late Harvest: Percentage Based on Non-Top Dressed Plats
Onley, Virginia	September 13, 1921		October 3, 1921	
1. 5-8-7 fertilizer No top dresser	232.1	100.0	313.4	100.0
2. 5-8-7 fertilizer NaCl top dresser	294.6	126.9	326.0	104.0
3. 5-8-0 fertilizer KCl top dresser	380.3	163.8	404.9	129.1
4. 5-8-7 fertilizer Na_2CO_4 top dresser	361.3	155.6	387.9	123.7
5. 5-8-0 fertilizer K_2SO_4 top dresser	294.0	126.6	255.0	113.2
Onley, Virginia	September 19, 1922		October 24, 1922	
1. 5-8-7 fertilizer No top dresser	179.0	100.0	193.4	100.0
2. 5-8-7 fertilizer NaCl top dresser	214.3	119.7	238.4	122.8
3. 5-8-0 fertilizer KCl top dresser	270.0	150.8	376.8	194.0
4. 5-8-7 fertilizer Na_2CO_4 top dresser	248.5	138.2	341.3	176.4
5. 5-8-0 fertilizer K_2SO_4 top dresser	245.0	137.0	385.7	199.4
Norfolk, Virginia	September 28, 1922		October 26, 1922	
1. 5-8-7 fertilizer No top dresser	271.4	100.0	296.6	100.0
2. 5-8-7 fertilizer NaCl top dresser	301.8	111.2	353.5	119.1
3. 5-8-0 fertilizer KCl top dresser	375.0	138.1	487.1	164.5
4. 5-8-7 fertilizer Na_2CO_4 top dresser	292.8	107.9	357.6	120.5
5. 5-8-0 fertilizer K_2SO_4 top dresser	323.2	119.8	331.9	111.9

crease. The sodium equivalent treated plats taken as a whole showed no superiority in yield over the potassium equivalent plats. In the same way the chloride equivalent plats compared very favorably with the sulphate equivalent plats, and again when taken as a whole, no deductions can be made as to the preference of the salts that give the highest yields when used as a top dresser.

Conclusion

Under the conditions of these experiments, sodium chloride as a top dresser resulted in a distinct increase in yields of sweet potatoes. There is no apparent relation between resultant yields of sweet potatoes from the various top dressed plats and the individual elements, or combinations of elements, that go to make up the salts. Since all the salts used as top dressers gave a decided increase of yield over the non-treated plats, it is evident that they exercise some common influence. This beneficial influence is manifested by an apparent increase in the rate of carbohydrate metabolism.

Influence of Fertilizers on the Yield and Form of the Sweet Potato

By L. G. Schermerhorn, *Experiment Station, New Brunswick, New Jersey*

THE Vegetable Department of the New Jersey Experiment Station has been carrying on plant food studies with the sweet potato for three years, beginning in 1921. The objects of these experiments have been to determine, (1) the best sources of nitrogen, (2) the influence of potash, (3) the best combination of fertilizer ingredients, (4) some of the factors that influence the shape of the sweet potato, and (5) the value of hill and tuber unit selections.

The work in 1921 consisted of a 21 mixture fertilizer triangle and a comparison of amounts of fertilizer in relation to yield, and occupied an area equivalent to about two acres. In the former, a comparison of balanced rations, a 4-8-4 was the basic formula. Each mixture was made up with the sum total of plant food elements amounting to 16. The three plant food elements, nitrogen, phosphoric acid, and potash, were each used in amounts varying from two to 12 per cent.

The work begun in 1921 was continued in 1922 and 1923, and additional experiments were carried out in order to check up on the facts brought out in the previous experiments. Additional potash studies were made in 1923, and additional comparisons of methods of applying nitrogen were also made in 1923, in an effort to confirm results secured in the previous years. The work in 1922 and 1923 occupied an area equivalent to three acres.

In all of these studies the plots were one-fortieth of an acre in extent and were run in duplicate, thus making the average records from one-twentieth of an acre. Accurate records have been kept of the plants lost during the growing season and the yields figured

on the basis of the actual number of plants left in the plots at digging time.

In this discussion it is my aim to show the results secured in our studies relating to sources of nitrogen, and the influence of potash on yield and form of the sweet potato.

Sources of Nitrogen

These results represent the average yields secured during the seasons of 1922 and 1923. In this experiment 1200 pounds per acre of 2-8-6 fertilizer mixture were used. Six hundred pounds were applied under the rows and the balance as a side dressing, three weeks after the plants were set in the field. The variety used was Yellow Jersey.

The sources of nitrogen compared were nitrate of soda, sulfate of ammonia, dry ground fish, and high grade tankage. These sources of nitrogen were compared alone and in combination.

The rank in the order of their yields per acre of marketable sweet potatoes over a two year period was as follows:—(1) tankage, 144.9 bushels, (2) fish, 135.7 bushels, (3) sulfate of ammonia, 133.3 bushels, (4) one half nitrate of soda and one-half fish, 126.9 bushels; (5) nitrate of soda, 111.7 bushels; (6) one-half nitrate of soda, one-half sulfate of ammonia, 106.2 bushels.

From these results it is apparent that an organic source is superior to either of the minerals, the tankage having the greatest influence in this direction.

Influence of Potash

Voorhees states that 200 bushels of sweet potatoes not including the vines, contain on the average 30 pounds of nitrogen, 10 pounds of phosphoric acid, and 45 pounds of potash.

T. E. Keitt of Clemson College, South Carolina, has shown in several analyses that the Yellow Nansemond, which is accepted as probably the same as Yellow Jersey, removed on the basis of a 214 bushels per acre yield .213 per cent nitrogen, .0519 per cent phosphoric acid, .39 per cent potash.

From these figures it is apparent that the sweet potato removes more potash than nitrogen, and more nitrogen than phosphoric acid. Experimental results secured during the past three years bear out the relative importance of each ingredient as shown in the above analyses.

The increase in yield has been very marked in comparisons between plots receiving no potash, four per cent potash and up to eight per cent potash, and a decrease in yield has been noted when 10 per cent or more was used. This same effect has been noted on white potatoes and tomatoes.

Another series of comparisons which shows the relation of the fertilizing ingredients to yields, is the average analyses secured on the seven high yielding, seven medium yielding, and the seven low yielding plots of the balanced ratio studies. The figures follow:

Two Year Average	Average Analyses	Yield in Bushels Firsts	Seconds
7 High Yielding Plots	3.4—5.2—7.1	171.0	99.3
7 Medium Yielding Plots	5.2—4.9—4.7	138.2	101.2
7 Low Yielding Plots	6.9—5.5—3.4	96.6	102.4

A comparison of these analyses shows that as the nitrogen increases and the potash decreases the yield of marketable tubers decreases, and vice versa when the potash is increased up to eight per cent and the nitrogen decreased to two or three per cent, there is a decided increase in yield. These figures also show that the phosphoric acid apparently plays a small part in the production of sweet potatoes as between all three of the average analyses the variation in phosphoric acid is only .3 per cent from 5.2 to 4.9.

Effect of Plant Food on the Form of the Sweet Potato

When the plots of the triangle were dug at the close of the season in 1922, marked differences in the form of the potatoes were noted upon the different plots, indicating that the amounts of the fertilizer elements used had influenced the shape of the potatoes. Ten average hills were selected from each plot and its duplicate and carried to New Brunswick for further study. The potatoes were graded from these hills into firsts, seconds, and culls, in the same manner as would be used in grading for the market. Each potato in each grade was then measured as to its length and diameter.

The results were so striking on the triangle, that when the other fertilizer plots were dug hills were selected and graded and measured in the same manner. In 1922 and 1923 nearly 35,000 sweet potatoes have been measured.

The influence of potash on form can be indicated by means of the following proportions, which show the relation of the length to the diameter. These measurements represent the average of all the potatoes from the plots receiving no potash, four per cent potash, six per cent potash, and eight per cent potash, and three per cent nitrogen, and eight per cent phosphoric acid.

3-8-0	6.9 x 1.66
3-8-4	5.6 x 2.06
3-8-6	5.39 x 2.24
3-8-8	5.47 x 2.19

The ideal proportion taking an average of the extremes allowed in lengths and diameters of fancy sweet potatoes according to the United States and New Jersey standard grades would be 4.5 x 2.5 or a coefficient of .55.

Influence of Nitrogen on Form

The results of our observations confirm a statement made by Dr. E. B. Voorhees, formerly director of the New Jersey Experiment Station, that excessive nitrogen produces a proportionately

long tuber. The measurements made on the potatoes from the triangle on the basis of a two year average show the following proportions:

2 per cent nitrogen	5.83 x 2.09
4 per cent nitrogen	6.0 x 2.05
6 per cent nitrogen	6.11 x 2.14
8 per cent nitrogen	5.64 x 1.87
10 per cent nitrogen	6.06 x 1.92
12 per cent nitrogen	6.8 x 1.93

Other Factors Influencing Form

It has been observed that, in a dry season such as was experienced in 1923, the general run of sweet potatoes is proportionately longer than in a season of normal rainfall.

It has also been observed that certain growers who produce their own strains of seed produce a large proportion of potatoes of desirable form, indicating that heredity might be a factor.

In order to determine what part heredity might play in the form of the sweet potato, two hills were selected in 1922, one was very desirable as to form and the other only a fair mother hill from the standpoint of ideal form. Plants from each mother hill were planted in two different places. In one place the resulting tubers from both mother plants were "chunky" and of good form, while in the other place the resulting tubers from both mother hills were longer and less desirable as to form than either of the mother hills. This indicates that environment exerts a great influence on the form of the sweet potato, and that in such a study as this last one it may be difficult to separate in some instances the influence of heredity and the influence of environment. The selection studies have been carried into the second generation and will be continued for several years, in the effort to determine if possible what are the inheritable characteristics of the sweet potato tuber in relation to form.

Another phase of sweet potato production which does not relate to form, but which we have been observing, is the great variation in color in the same variety and in the same strain of the Jersey type of sweet potato. I have in mind one grower who is able to produce a bright yellowish-brown potato of very desirable form every year. A neighbor purchases seed of this man and sets out plants on his farm and he secured a desirable form somewhat different from the original, but the color is much lighter than that secured by the first man. This presents a problem aside from form and shows how sensitive the sweet potato plant is to its environment.

Studies in Sweet Corn Germination in Relation to the Effects of Moisture Content and Temperature

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Introduction

Sweet corn seed is notoriously deficient in its ability to germinate. This inability is commonly attributed to careless handling in harvesting or storing, although some gardeners express the belief that vital weakness of sweet corn is an inherent trait. Much work has been done with dent corn which demonstrates that freezing weather combined with immature development of the corn, is responsible for considerable seed of low germinability.

In undertaking these studies with sweet corn it has been the purpose to determine what the important factors are influencing germinability, especially in relation to the effects of moisture and temperature. Inasmuch as these are factors of importance with dent corn, they are commonly considered by gardeners as equally important with sweet corn. Although there is much confirmatory evidence with respect to dent corn (Zea mays indentata) and many other seeds, it has been assumed with but little investigation that the same conditions have the same effect on sweet corn (Zea mays saccharata). Special attention has been given to a study of the relation between conditions of moisture and temperature and death of the embryo, with the aim of discovering to what extent these factors affect the vitality of seeds of this plant.

Historial Review

In agreement with practical gardeners, some botanists and horticulturists, notably Duvel, Becquerel, Kiesselbach, and Babcock, studying dent corn, express the belief that dry, mature seed corn gathered well in advance of frost and stored in a dry, well ventilated place possesses greater germinability than immature corn exposed to low temperature in the field or in storage.

The work of Kiesselbach and Ratcliff is noteworthy. They found that dent corn above 20 per cent moisture is likely to be impaired by even a slight or autumnal frost, whereas such seed with as low as 10 per cent moisture will withstand the most severe winter freezing without affecting the germinability. P. Becquerel showed that dry corn seeds can be subjected to temperatures as low as minus 192°C. without injury, whereas seeds of corn with a sufficiently high percentage of water and gas have their cell nuclei and protoplasm disorganized, rendering germination impossible. Brown and Escombe in their freezing of dry corn seeds containing 10 to 12 per cent of moisture, agreed that germinability was not appreciably impaired by one hundred and ten hours at the lowest temperature obtainable in liquid air (minus 183° to minus 193°C).

According to Giglioli the ancients emphasized dryness of the seed and preservation from moist air as being essential to the latent secular vitality of their Mummy Wheat and other seeds stored in Pompeii and Herculaneum. The splendid research of Duvel in the United States Department of Agriculture, and that of many other investigators, have led them to the same conclusion with regard to seeds from a wide range of families of plants.

Inasmuch as most investigators concur in the belief that moisture and temperature play important roles in the vital phenomena of seeds, it was deemed advisable to determine if possible the manner in which low temperature and high percentage of moisture, in which we are particularly interested, affects the seed causing the suspension of vital activity, and finally death.

Theories of Death by Freezing

A review of the literature dealing with a wide range of plant materials reveals many and varied views regarding the cause of injury including: (1) a theory of crushing or rupturing of cell structures, (2) injury or death from too rapid thawing, (3) desiccation of protoplasm, and (4) the most recent theory, of physical and chemical disorganization of protoplasm and other cell contents.

Many early writers, including Geopert and Sachs, whose work cannot be discussed here, inclined toward the belief that plant cells were broken in freezing. Sachs was a more ardent supporter, however, of the theory of death by rapid thawing and also by desiccation of the nuclear material. More recent investigators, notably Chandler and Weigand, have expressed the belief that cells of some plant tissues are broken in freezing due to the increased tension exerted by a change in volume from a liquid to a solid. Salmon, however, discounts the whole theory as being untenable, in view of our knowledge of cellular structure. Chandler in turn is opposed to the theory of injury from rapid thawing, with a few exceptions. Adams, on the other hand, championed the theory, finding that ice melted and was reabsorbed if thawing be gradual. Adams could not, however, be converted to the popular belief that desiccation by freezing was ever the cause of death since dry seeds containing 12 per cent moisture were not killed by freezing when it had been demonstrated by Ewart that the amount critical for life was below 3 per cent. In support of the theory of physical and chemical disorganization by freezing, the work of Detmer is rather conclusive. He points out that frozen red beets if put in water lose their coloring matter, whereas, the unfrozen tissue tenaciously holds it. Kiesselbach and Ratcliff contribute to this explanation.

Personal Interpretation

To determine to what extent these theories could be applied to sweet corn, both seeds and seedlings were examined microscopically before and after freezing at about zero degrees F. and after being thawed gradually in moist sand and quickly in an oven. It was found that breaking of any of the cell structure is not of frequent occurrence, none being observed in the sections of tender root tips and only two in the embryonic tissues of moist seeds that have

been thawed slowly in moist sand in a greenhouse at 60° to 70°F. after freezing. No rupturing whatever was noticed in dry seeds of 10 per cent moisture regardless of the speed of thawing. With respect to desiccation, the cells of seeds with a high content of water had unquestionably lost water to the intercellular spaces upon freezing, although no such change was discernible in dry seeds when examined while in the frozen condition. Whether or not water had been withdrawn from the cells below the minimum required to sustain life, is extremely doubtful. A change in color and later spoiling of all the moist frozen, and some of the dry material, was noted, lending considerable support to the theory that death in sweet corn ultimately results from physical and chemical disorganization. Although mild rupturing was observed in the section cited, and rapid thawing may affect a physical and chemical change, it is doubtful in light of these observations if any explanation of the phenomena of freezing is as reasonable as that of protoplasmic disorganization by physical and chemical means. It is conceivable that the freezing of water withdrawn to the intercellular spaces may rupture surrounding tissue by a change in volume, but that action could not be attributed to desiccation and would seem to be only contributory to, rather than the final cause of, death. In view of the discoloration observed with frozen specimens of moist seeds and the work done by other investigators, it would seem logical that some change is undergone by the hyloplasmic layers during or after freezing, making them pervious to water and permitting cellular fluids to leave the plasma as a result of the disorganization of the protoplasm.

Germination of Sweet Corn Seed Before and After Frost

A consideration of these theories serves to emphasize the need of determining what conditions of temperature and moisture are critical with sweet corn seed. Pursuant to these ends, sweet corn (Stowell Evergreen) was gathered in the field in late summer before frost, and after frost in the fall. Both mature and immature seed was harvested and the moisture determinations made. Study was made in three widely separated states over a period of three years. After drying in storage, samples of 100 seeds each were tested in quadruplicate for germinability with the results shown in Table I. The site at South Bend, Indiana, was in low, muck ground, while that at Lebanon, Boone County, Indiana, was on high, average corn ground.

It appears that mature and immature seed gathered before frost being about equal in germinability should be equally viable when used for seed. It might further be concluded from these data that seed produced in all sections represented, with the exception of that at South Bend on low ground, has equal ability to germinate, variations being within the range of experimental error, with that exception.

TABLE I.

Average Germination of Mature and Immature Corn Gathered Before Frost.

Ames, Iowa 1921	*South Bend, Indiana 1922*	*Washington, D. C. 1922*	*Boone County, Indiana 1923*
	Mature Corn		
100	100	100	99
100	98	...	100
98	90	...	...
100	92	...	...
	Immature Corn		
100	98	100	100
100	100	...	98
96	88	...	...

To determine what effect frost has on seed corn in the mature stage and in the immature milk stage samples of corn, were gathered after frost and their germination also tested in quadruplicate. Averages of the results are submitted in Table II.

TABLE II.

Average Germination of Mature and Immature Corn Gathered After Frost.

Ames, Iowa 1921	*South Bend, Indiana 1922*	*Washington, D. C. 1922*	*Boone County, Indiana 1923*
	Mature		
100	98	100	98
100	96	...	100
100	96	...	...
100	100	...	...
	Immature		
20	0	0	0
0	0	...	6
0	0	...	...
16	0	...	...

From these figures, it is evident that sweet corn in the milk stage, which averaged in this instance between 55 and 60 per cent moisture (wet weight), is seriously injured by being exposed to the action of frosts while in that condition. On the other hand, seed which had matured considerably in advance of the coming of frost averaging between 15 and 18 per cent moisture, and subjected to the same exposure is shown to be unimpaired in germinability, and

upon comparison with corn gathered before frost (Table I) seems to be equally germinable. But the immature corn gathered after frost (Table II) is obviously weaker in germination than corn harvested before frost (Table I). The conclusion appears to be most positive that corn in the milk stage is unable to survive the effects of heavy frost.

Humidity

Since the moisture content of the seed is found to have an important bearing on its germinability, it seems logical to suspect that humidity of the air is also a factor. In this connection, it is interesting to note the observation made on sweet corn grown in different localities in Indiana in 1922 and 1923, in which corn was grown simultaneously under conditions of low and high humidity. The corn which is grown under conditions of high humidity was situated on muck soil near South Bend, Indiana. This land lying considerably lower than that to the south was visited by a frost fully three weeks before its occurrence on high ground where corn was planted in Boone County, Indiana, the first frost this year (1922) on muck soil occurring on September 25, while on the higher ground frost did not come until October 19, of that year. Likewise the germinability of the muck grown seed was appreciably injured three weeks earlier than that on high ground.

These results indicate that the combination of high humidity and low temperature characteristic in general of low grounds and muck soils, causes the germinability of seeds to be affected earlier by frost than corn at the same stage of maturity is affected on higher ground where lower humidity prevails.

In respect to the relative germinability of corn grown in widely separated sections, the frost records of the United States Weather Bureau reveal that little frost difference existed in the representative localities of those sections during 1922 and only slightly more in 1921. If space permitted to present these statistics they would possibly justify the belief that corn produced under similar conditions in these sections representative of the West, Central West and East possess about equal ability to germinate. This information would seem to make the prejudice against western grown sweet corn seed unwarranted in comparison with eastern grown seed, for seed purposes. The prejudice can possibly be traced to the discrimination against western canned sweet corn which is generally believed to be inferior to sweet corn canned from eastern growing sections.

However, the experience of the writer would indicate that sweet corn properly grown in the Central West is equal in quality to that produced by any other region. Canning tests were made with the most prominent varieties in 1922 and 1923, grown on muck soil, and in them the sweetness and tenderness were found not to be inferior to the canned product offered on the market from eastern sources. Seed grown in the Central West was used to produce the corn used in the canning tests.

From these observations the conclusion would seem warranted that the germinability and quality of sweet corn being about the

same in the eastern and western sections where tested, conditions in these sections should be considered about equally favorable for the development and germination of seed sweet corn.

Tests of Corn Exposed to Winter Temperature

As mature sweet corn, as previously noted, displayed marked resistence to the influence of frost, the question was raised in Iowa as to how germination would be affected by corn being exposed to more extreme conditions. Germination tests were made from September to January from early matured ears that had been left in the field exposed to frost and the rigors of winter. The results of the germination tests show that even mature corn was severely injured by long exposure to low temperatures and moist air. During the period of harvest the temperature was frequently near the zero F. point, and on one date near the end of harvest went as low as minus 20°F.

These observations would seem to enforce the simple injunction that sweet corn intended for seed purposes should be protected from exposure to very inclement winter weather conditions. Although not always killed by extreme cold and humid weather conditions, the seed is seriously injured in vigor.

Freezing Artificially

Since in all the preceding studies made of sweet corn germination, the measure of germinability was so frequently found to be correlated with temperature, and the percentage moisture of the seed, it was considered desirable to duplicate these tests under artificial conditions throughout the winter, when a comparative study of mature and immature corn could not be made from the field. This, of course, necessitated devising a means of controlling in the laboratory, the raising of the moisture content of dry seed held in storage as high as that of the corn at various stages of maturity had been in the field, in order to imitate immature conditions, prevailing in the field. The seed was soaked in water at 25°C. until the required percentage of water was held to compare with samples of similar corn gathered in the field. This artificially imbibed water raised many questions, among them, the rate of imbibition and the value of such corn in making comparisons with corn tested directly from the field earlier in the season. This study made of imbibition is described later in more detail.

After seeds had attained the required percentages of moisture they were exposed to the desired temperature by being placed in refrigerating chambers regulated in temperature by various mixtures of ice and salt. Equal quantities of all samples of corn were exposed to a temperature of 22°F. for four different periods, namely, for 24 hours, 48 hours, 72 hours, and 96 hours. Since dent corn (variety Hogue Yellow Dent) was used in the study of imbibition, samples were soaked for similar lengths of time as, and included with, sweet corn in the cooling chambers.

The results indicated that sweet corn of high moisture content is more susceptible to injury than is drier corn, confirming those results obtained with corn frozen under natural field conditions, generally speaking. Sweet corn above 50 per cent moisture was

almost completely killed, and severely injured when containing half that amount. Dent corn samples were practically all killed after attaining 70 per cent moisture, showing marked impairment of germinability with less than half that percentage. There seemed to be no appreciable difference in the severity of the injury between samples frozen for 24 hours and those frozen for longer periods up to 96 hours.

For the gardener or seedsman, it would seem to follow that sweet corn, which is of paramount interest here, is injured by a temperature only 10 degrees below freezing, even though the moisture content of the seed is only moderately high. The fact that sweet corn was injured seriously with 20 per cent less moisture than field corn, indicates that sweet corn dryness is more essential at harvest and in storage than it is with field, or dent corn.

Absorption Studies

Before proceeding with the study of artifically frozen corn, it was necessary to make a preliminary investigation of the rate at which seeds absorbed water, since corn of different moisture contents was required for this test, and since the corn in storage had become dry and of a uniformly low per cent of moisture. It may be seen that if the rate is found to proceed with any regularity that laws might be formulated to determine the length of time necessary for seeds to imbibe any given percentage of water, at a given temperature.

With this end in view, samples of 20 seeds each of sweet and dent corn in quadruplicate were placed in distilled water at room temperature of 25°C. Samples were of known weight and tested 9.1 per cent water. Weighings were made to three decimals, in glass-stoppered bottles. Future moisture determinations were made by calculating the percentage of gain over this original. At the end of certain periods from one to 241½ hours, the seeds were taken out of the water, quickly dried with absorbent gauze, and weighed. The rate of absorption proved to be so nearly uniform in all samples that the formulation of laws within rather narrow limits was possible. This and subsequent studies, however, pointed out that the rate of gain during the first few hours is intermittently rapid and slow, making it difficult at that stage to determine accurately the amount absorbed during a shorter period than an hour, although definite trends might be found. But as the imbibition proceeds, the rate becomes more regular, and the amount of time required for the seed to imbibe any given percentage of water may be determined with much greater accuracy until the seeds begin to grow, this usually beginning after about 50 hours. It is not possible here to submit tables, or graphs, in detail covering the entire period of observation of any group of these samples, each one being weighed and given almost constant attention over a period of ten days and nights. Suffice it to say that laws were formulated for obtaining seed-moisture within certain ranges of percentage with equivalents of time limits for soaking. To be conservative, these laws, as summarized in Table III, are given with the time and moisture limits generously wide with the belief that they will be

adaptable to other samples of corn that are in less uniform condition, and yet be close enough to permit of accurate work, with the exercise of judgment, in the hands of another investigator.

TABLE III

Dent Corn Laws for Corn Containing between 8 and 10 per cent Moisture		Sweet Corn Laws for Corn Containing Between 9 and 11 per cent Moisture	
To obtain:	Soak at 25° C for:	To obtain:	Soak at 25° C for:
0— 12 per cent	0 — 1 hr.	0— 9 per cent	0— 1 hr.
12— 17 per cent	1 — 2 hrs	9— 14 per cent	1— 2 hrs.
17— 25 per cent	2 — 4 hrs.	14— 20 per cent	2— 4 hrs.
25 — 35 per cent	4 — 7 hrs.	20— 25 per cent	4— 7 hrs.
35— 40 per cent	7 — 9 hrs	25— 30 per cent	7— 9 hrs.
40— 45 per cent	9 — 12 hrs.	30— 35 per cent	9— 11 hrs.
45— 50 per cent	12 — 15½ hrs.	35— 40 per cent	14— 22 hrs.
50— 60 per cent	15½ — 24 hrs.	40— 45 per cent	22— 28 hrs.
60— 70 per cent	24 — 32 hrs.	45— 50 per cent	28— 42 hrs.
70— 80 per cent	32 — 50 hrs.	50— 55 per cent	42— 55 hrs.
80— 90 per cent	50 — 74 hrs.	55 — 60 per cent	55— 75 hrs.
90—100 per cent	74 —100 hrs.	60— 65 per cent	75— 88 hrs.
100—110 per cent	100 —148 hrs.	65— 70 per cent	88—124 hrs.
110—115 per cent	148 —175 hrs.	70— 75 per cent	124—173 hrs.
Sprouting and growth		Sprouting and growth	

It is observed that sweet corn absorbs at a faster rate than dent corn, imbibing as much as 20 per cent more water in the same length of time after immersion for 20 hours or more. Although this study is chiefly of botanical interest, is there not a practical suggestion in this fact? In view of the studies in freezing, it suggests that sweet corn is more susceptible to frost injury than dent corn in the same atmosphere. If so, it also reiterates the necessity for greater care in harvesting and storing sweet corn than dent corn.

Incidentally, it might be mentioned that two types of sweet corn were brought under observation in the course of the study of absorption: the ordinary thin-kerneled, wrinkled type, and the plump, smooth type, both mature and air-dry. The smooth, thick, plump-kerneled type absorbing less water than the thin, wrinkled one, common to sweet corn growers, I am led to believe, that from the viewpoint of hardiness, the smooth type is superior to the wrinkled. There is, in the admission of this point, the possibility of creating a strain of sweet corn better adapted to being grown in colder climates and in muck areas with short growing seasons, restricted for the most part by late and early frosts.

STORAGE

The inferences drawn from each of the studies here discussed all point to the need of more definite information as to what the optimum conditions for storage of sweet corn are. The percentage of moisture being such an important factor influencing the injury of seed by frost, indicates that humidity and temperature of the storage house are of prime importance in contemplating the keeping of the corn after it is properly harvested. In this connection,

the question arises as to the optimum conditions for drying, which process seems to be essential. Although there are approved methods of drying and storing sweet corn seed, there is reason to believe that some criticism could be offered of prevailing practices. It was purposed by the author to consider all the methods of drying and storing corn now in vogue and to devise some plan which provided for the characteristics found to be peculiar to sweet corn. But an acute illness overtook the writer while conducting these studies, while facilities and time since have not permitted of making this further study. It appears to be a problem of such magnitude as to warrant a comprehensive investigation.

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Observations on the Effect of Liming Truck Crops in Ohio

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EXPERIMENTS to determine the effect of lime on truck crops in Ohio are being conducted in two widely different sections of the state by the Ohio Agricultural Experiment Station. One experiment is located in the Marietta trucking district in southeastern Ohio (Washington County), and the other on the Station grounds at Wooster.

The soil at Marietta is of alluvial origin, light in texture containing considerable gravel and ranges from slightly acid to neutral in reaction. The farm was in a very low state of fertility when taken by the station for experimental purposes. A soil improvement series was instituted in 1915, using various combinations of lime, manure and chemical fertilizers on a four year rotation of early sweet corn, early cucumbers, early cabbage and early staked tomatoes. The manure is plowed under and the lime and chemical fertilizers broadcasted and worked into the soil before planting. Cowpeas are used as a cover crop after sweet corn, cabbage and tomatoes and rye after the cucumbers.

A summary of the effects of eight years continuous applications of limestone to three basis soil treatments on four truck crops, is presented in Table I.

Table I

Effect of One Ton of Limestone per Year on Truck Crops at Marietta, Ohio. Eight Year Average—1915 to 1922

	Calculated Yield per Acre in Pounds			
Treatment.	Corn	Cucumbers	Tomatoes	Cabbage
1 No treatment (average 2 checks)	6403	12409	6104	13906
1 ton ground limestone	7290	13617	6725	17335
Increase in pounds	887	1208	621	3429
Increase in per cent	13.85	9.73	10.17	24.65
Value of increase (1)	$15.26	$19.06	$22.49	$72.72
Net value of increase (2) ...	$10.26	$14.06	$17.49	$67.72
2 16 ton manure (average 2 plots)	8599	20876	13051	22705
16 ton manure plus 1 ton limestone	8762	22242	13594	23560
Increase in pounds	163	1366	543	855
Increase in per cent	1.89	6.54	4.16	3.76
Value of increase	$2.80	$21.55	$19.67	$18.13
Net value of increase	—$2.20	$16.55	$14.67	$13.13

3 610 lb. 4.2—10.5—4.1	7960	20875	9695	20560
610 lb. 4.2—10.5—4.1 plus 1 ton limestone	8065	20194	9126	22360
Increase in pounds	105	—681	—569	1800
Increase in per cent	1.32	—3.26	—5.86	8.75
Value of increase	$1.80	—$10.74	—$20.61	$38.17
Net value of increase	$3.20	—$15.74	—$25.61	$33.17

(1) 8 year average price per pound; corn $.01721, cucumbers $.01578, tomatoes $.03623, cabbage $.02121.

(2) Value of increase less $5.00, the cost of lime application.

TABLE I.

The first line in treatment 1 gives the production of the soil with no fertilizer, and the first line in each succeeding treatment gives this production as influenced by the basic fertilizer. Note that the unlimed production of treatment 3 is almost equal to that of treatment 2, although the manure contained five times as much nitrogen and potash and the same amount of phosphoric acid as the chemical fertilizer. Williams (1) has estimated that there were eight pounds of nitrogen and potash and four pounds of phosphoric acid to the ton in the manure used in treatment 2. The beneficial effect of lime on corn, cucumbers and tomatoes is much greater on the manure treated plot than on the chemical fertilizer plot. The addition of lime to the chemical fertilizers reduced appreciably the production of both cucumbers and tomatoes.

The application of 1 ton of ground limestone applied costs $5.00 (1) and deducting this from the value of the increase gives the net increase due to the lime. These figures show that lime returns a profit on the investment on all the crops when no other treatment is given; on all except sweet corn when added to 16 tons of manure; and only on cabbage when added to 610 pounds of a 4.2—10.5—4.1 mixture. Cabbage is the only crop to show a profit from the use of lime on all the treatments.

In view of the following facts: (1) one ton of limestone has been applied every year on a soil that was only slightly acid; (2) only one of the crops grown according to the Rhode Island work is supposed to show more than a slight increase by liming a slightly acid soil; (3) the percentage increase from lime on all crops is greatest when no other treatment is given; and (4) there is still an increase when lime is added to large amounts of plant food as is contained in 16 tons of manure; it is apparent that other factors than the neutralizing effect of lime must be taken into consideration in explaining the benefits and detriments derived from its use.

Thompson (2) says a large part of the beneficial effects of lime may be attributed to "its indirect benefits, such as promoting the decomposition of organic compounds, providing favorable conditions for nitrification, assisting the growth of nitrogen gathering organisms associated with leguminous cover crops," and "in converting insoluble forms of potassium and phosphorous into soluble forms." It should be noted in this connection that although the percentage increase from lime on cucumbers in the manured plots was not as great as on the unfertilized, the percentage increase was greater than on the other crops in the same treatment, showing that

lime had a greater beneficial effect on the manure for cucumbers than for the others.

Soil conditions at Wooster are very different from those at Marietta. The soil is a "Wooster silt loam," very infertile, containing some shale, low in organic matter and strongly acid in reaction. Tile drains were laid through the middle of each plot in the fall of 1922. The soil is heavy and cold and it is impossible to secure first early crops. Early sweet corn, dry white kidney beans, main crop tomatoes and early cabbage, are grown in a four year rotation. Various combinations of manure and commercial fertilizers are used and half of each plot is limed each year with 1000 pounds per acre of ground limestone. Rye is used as a cover crop after the crops are harvested.

TABLE II

Effect of 1000 Pounds Ground Limestone per Year on Truck Crops at Wooster, Ohio. Two Year Average, 1922-1923

Treatment.	Calculated Yield per Acre in Pounds		
1 No treatment (average of 4 plots)	6802	11590	12124
1000 pounds limestone	7253	13576	13438
Increase in pounds	651	1986	1314
Increase in per cent	9.57	17.13	10.83
Value of increase (1)	8.46	$9.93	$26.28
Net value of increase (2)	$5.96	$7.43	$23.78
2 8 T. manure plus 320 pounds acid phosphate	6246	23070	15179
8 T. manure plus 320 pounds acid phosphate plus 1000 pounds limestone	7548	22010	16010
Increase in pounds	1302	—970	831
Increase in per cent	20.84	—4.2	5.47
Value of increase	$16.92	$—4.85	$16.62
Net value of increase	$14.42	$—7.35	$14.12
3 1000 pounds 4—9.6—7.5	8035	24308	15344
1000 pounds 4—9.6—7.5 plus 1000 pounds limestone	8478	24300	17284
Increase in pounds	443	—8	1940
Increase in per cent	5.51	—.03	12.64
Value of increase	$5.75	$—.04	$38.80
Net value of increase	$3.25	$—2.54	$36.30

(1) Value per pound corn $.013, tomatoes $.005, cabbage $.02.
(2) Value of increase less $2.50, cost of lime application.

The treatments in Table II are different from those in Table I, but are the nearest obtainable for the purpose of comparison.

TABLE II

The results as presented in Table II are not of great significance when considered alone because of the short duration of the experiment, but it is interesting to note that the results in general agree with the work at Marietta. Cabbage and sweet corn show an increase in yield from the line on all treatments, but the percentage increase, except in tomatoes, in the unfertilized plots at Wooster, is less than at Marietta. It is probable that applications of

ground limestone larger than 1000 pounds per acre would give larger yields. This is further supported by the fact that the percentage increase in cabbage in 1923 was higher than 1922, and it is expected that it will continue to increase as the acidity becomes neutralized.

Tomatoes, on the other hand, show a loss by the addition of ground limestone on the fertilized plots in Table II. If all the fertilized plots at Wooster are taken into consideration the average yield of ripe tomatoes increased 7.66 per cent from the application of lime, the yields of ripe fruit for the first half of the picking season increased 3 per cent and the amount of green fruit on the vines at the end of the season decreased 2 per cent. Averaging the effect of lime on the unfertilized check plots shows an increase in the yield of ripe fruit of 17.13 per cent, an increase in the yield during the first half of the harvesting season of 8 per cent, and a 4.8 per cent decrease in the amount of green fruit at the time of frost. Dr. Thorne of the Ohio Station in the general farm rotation work, has found less effect from the use of lime on manured land. He also found less effect when nitrate of soda, or acid phosphate, was used in connection with lime.

In averaging the yields of cabbage from all of the fertilized treatments at Wooster, the increase from the addition of lime has been 9.68 per cent and on the check plots 9.44 per cent. Sweet corn shows an average increase of 6.8 per cent on the fertilized plots, and 6.99 per cent on the check plots.

The detrimental effect of limestone when added to chemical fertilizer on tomatoes and cucumbers warrants explanation. The usual practice in applying these materials is to broadcast the lime immediately after plowing and then to work it into the soil by harrowing or discing. The chemical fertilizers are usually broadcasted a short time before planting. In a spring, when the season is late, only a short time elapses between the two applications. It is reasonable then to predict or expect that the large excess of lime applied to a soil already well supplied with calcium would react with the acid phosphate changing it into the more insoluble tricalcium phosphate. If enough of the soluble form is changed into the insoluble form, the lack of soluble phosphate would become the limiting factor in production and could produce the decrease noted.

If this hypothesis be true then the amounts of both fertilizers used would influence the result. Such seems to be the case in the treatments at Wooster. On a plot receiving manure and acid phosphate with a total phosphoric acid content of 81.2 pounds, 1000 pounds of ground limestone reduced the production 4.2 per cent. In a chemically treated plot which received 96 pounds of phosphoric acid, 1000 pounds of ground limestone only reduced the production .03 per cent. On a limed soil of this character then it would take over 600 pounds more acid phosphate than on unlimed soil to produce the same crop.

The question now arises, why do cabbage and corn show an increase, while cucumbers and tomatoes show a decrease under the

same conditions. Truog's (4) theory regarding the feeding power of plants throws some light on this question. The reason seems to be in the differences existing in the feeding power of the various plants on tricalcium phosphate. According to Truog the feeding power of plants for raw rock phosphate, which is largely tricalcium phosphate, is dependent upon the calcium oxide intake of the plant. Crops having a high calcium oxide content have a relatively high feeding power for raw rock phosphate and for those with a low calcium oxide content the converse is true. Cabbage is given as one having a high feeding power for raw rock phosphate, and ash analysis (Sherman 5) shows that the calcium oxide content of the plants involved ranges downward in the following order: cabbage, corn, cucumbers and tomatoes. According to this we would expect tomatoes to show the least response, and cabbage the most from the use of phosphorous carriers in the presence of excessive amounts of lime, with the others ranging in between. By reference to treatment 3, Table I, we find that such is the case.

Summary

1. Sweet corn, cucumbers, tomatoes, and cabbage, return a large profit from the use of large amounts of ground limestone to soil that receives no other treatment except a cowpea cover crop.

2. Large amounts of ground limestone are profitable even when added to large quantities of manure for cucumbers, tomatoes and cabbage.

3. Cabbage particularly responds to large quantities of ground limestone profitably, under most soil treatments.

4. Decreases in yield on some crops where lime and acid phosphate are both applied the same season may be due to chemical reactions which result in a decreased availability of phosphate for the affected plants. The crops affected by this reaction are usually those with a low feeding power for raw rock phosphate such as the tomato, cucumber, watermelon, muskmelon, egg plant and potato.

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Abbreviation of the Dormant Period in Potato Tubers

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ONE of the practical problems in investigations on dormancy in plants is to devise a treatment which will result in prompt, uniform sprouting when dormant, or partly dormant, seed tubers are planted. In certain regions, notably the coastal region of Southern California, and in Arkansas and Oklahoma, it is customary to plant potatoes produced by spring crop as seed for a second or fall crop. Usually a poor stand results, thus in Southern California there is frequently not over a 50 to 60 per cent stand in the fall crop. In other regions, where the product of the fall crop from Virginia and New Jersey is used for planting the spring crop, slow and irregular sprouting often results, thus handicapping the use of such seed, as compared to the prompt sprouting of seed secured from Maine and New York. Experimental data on this point have been reported by the writer (1) and others.

Various methods of breaking the dormant period in potatoes have been reported though the mechanism by which growth releasal is accomplished, has not been explained. McCallum (2) states that buds of dormant tubers were stimulated to activity by 24-hour exposure to ethyl bromide, 0.5 cc. per 5 litre chamber, and by approximately the same strength of ammonia, gasoline, carbon tetra-chloride and ethylene chloride. The details of his experiments have never been published to the writer's knowledge. Appleman (3) likewise demonstrated the efficiency of ethyl bromide gas in setting into motion the growth processes in dormant buds on cut pieces of potato tuber. He further showed that the dormant period of potato tubers can be shortened, or eliminated, by any means that permits access of oxygen to the interior of the tuber. Appleman found that the suberization of the skin, or of cut surfaces, greatly reduced permeability to water and to gases. It is the object of this paper to describe new methods of breaking the dormancy of potatoes which are adapted to field practice and to suggest a theory concerning the breaking of the rest period.

In some experiments begun at Davis, California, November 16th, 1922, a very marked stimulation of sprouting appeared where dormant seed pieces were planted in soil to which nitrate of soda had been added. The results from duplicate plots were as follows, in per cent of sprouts above ground.

	Dec. 15	Jan. 3	Feb. 2	Mar. 2
With nitrogen ..	17 per cent	82 per cent	82 per cent	100 per cent
Without nitrogen	0 per cent	3 per cent	33 per cent	80 per cent

The potatoes used in this test were newly dug Russett Burbanks. About the same time Newton (4) was obtaining results of

a similar nature, where dormant tubers were planted in sand, to which nutrient solutions with and without nitrates had been added.

Following these results, several series of experiments have been carried out by the writer, using potatoes at different stages in the dormant period. The method followed in all experiments has been to place the cut seed pieces in solutions of varying composition and concentration, for a definite length of time, after which they were promptly planted, either in the field or in the greenhouse. Microchemical tests showed that the corky periderm of potato tubers was not permeable to NO_3, while it was rapidly absorbed by cells adjoining freshly cut surfaces. Hence the tubers in all the experiments both with nitrates and other substances, were cut to the usual seed piece size before treatment. The apical and basal portion of the tubers have usually been discarded.

For convenience, the results of such portions of these experiments as are pertinent to this report have been summarized in Table 1. The term "germination" is used to designate the sprouting of the buds and the emergence of the shoots at the surface of the soil. The seed pieces were planted uniformly at a depth of three inches in the greenhouse tests. In the field test they were planted with an Iron Age planting machine at a depth of four inches. For each experiment, the percentage of germination (per cent of seed pieces having sprouts above ground) and the average numbers of days required for the appearance of the sprouts are given. The experiments fall into two groups; in those terminated when the germination was approximately completed, the second column indicates that the average number of days required for germination was longest in the checks. In experiments terminated earlier, the chief difference is the greater per cent germination in the treated lots. The results of some of the experiments are shown graphically in Plate 1, percentage germination being plotted against number of days after planting. Fig. 1 is taken from experiment No. 2, and Figs. 2 and 3 from Experiment No. 3.

The following list gives the time and other conditions of the various experiments:

Experiment No. 1 Began Jan. 8, ended March 23, 1923. Fall crop White Rose. In greenhouse.

Experiment No. 2 Began Feb. 23, ended April 26, 1923. Fall crop White Rose. Main crop Russetts. In field.

Experiment No. 3 Began Oct. 10, ended Dec. 2, 1923. Summer crop White Rose. In greenhouse.

Experiment No. 4 Began Oct. 25, ended Dec. 2, 1923. Summer crop White Rose. In greenhouse.

Experiment No. 5 Began Oct. 30, ended Dec. 14, 1923, Summer crop Russetts. In greenhouse.

Experiment No. 6 Began Nov. 5, ended Dec. 14, 1923. Summer crop Russetts. In greenhouse.

TABLE 1

Effect of Chemical Treatments Upon "Germination" of Dormant Seed Pieces

Material Used		Time	Experiment Number 1 Per cent germinate	Experiment Number 1 Average days to germinate	Experiment Number 2 Per cent germinate	Experiment Number 2 Average days to germinate	Experiment Number 3 Per cent germinate	Experiment Number 3 Average days to germinate	Experiment Number 4 Per cent germinate	Experiment Number 4 Average days to germinate
White Rose Variety										
Check	....	....	100	53	82	50	30.8	28.5	71.4	19.4
$NaNO_3$	1.0 M ..	1 hour	47	46	...	..	....	....	....	....
"	0.5 M ..	0.5 hour	100	35	...	..	....	....	....	....
"	0.5 M ..	1 hour	96	33	100	37	78.1	23.4	93.0	18.1
$Ca(NO_3)_2$	.25 M ..	1 hour	...	..	...	..	31.2	32.6	....	....
$Mg(NO_3)_2$	.25 M ..	1 hour	...	..	...	..	48.3	27.1	....	....
$Mn(NO_3)_2$	.25 M ..	1 hour	...	..	...	..	....	....	78.5	18.2
$KMnO_4$	.01 M ..	1 hour	...	..	...	..	81.1	24.6	....	....
$(NH_4)_2SO_4$	.25 M ..	1 hour	...	..	...	..	57.1	23.4	....	....
$FeCl_3$	.01 M ..	1 hour	...	..	...	..	....	....	85.6	19.8

Material Used		Time	Experiment Number 2 Per cent germinate	Experiment Number 2 Average days to germinate	Experiment Number 5 Per cent germinate	Experiment Number 5 Average days to germinate	Experiment Number 6 Per cent germinate	Experiment Number 6 Average days to germinate
Russett Burbank Variety								
Check	....	......	89	45.8	14.3	34.0	33.3	28.0
$NaNO_3$	0.5 M	1 hour	100	36.7	78.6	27.1	92.8	24.8
$KMnO_4$	0.01 M	1 hour	...	....	....	....	72.6	24.0
$SnCl_4$	.1 M	1 hour	...	....	41.7	33.0	....	....
"	.01 M	1 hour	...	....	....	....	53.8	20.7
$SnCl^2$	.1 M	1 hour	...	....	66.6	29.2	....	....
"	.01 M	1 hour	...	....	....	....	64.2	22.8
$FeCl_3$	.1 M	1 hour	...	....	23.1	30.0	....	....
"	.01 M	1 hour	...	....	....	....	84.6	23.2
$FeCl_2$	.01 M	1 hour	...	....	33.3	39.0	....	....
"	.001 M	1 hour	...	....	....	....	69.2	24.1
NaCl	.1 M	1 hour	...	....	....	....	27.6	35.7
$NaNO_3$	.1 M	1 hour	...	....	....	....	16.6	23.0

From Table 1, it appears that the per cent of germination of dormant seed pieces has been increased by treatment with a variety of substances. Also the time required for emergence of the shoots has been decreased. Sodium nitrate in 0.5 molar concentration has been the most effective, apparently. On the other hand, magnesium and calcium nitrate have had no such effect in the single experiment in which they were used. Presumably, the absorbtion of the NO_3 ion is much less when it is associated with the bivalent cations, Mg and Ca than when associated with the univalent Na. Stiles and Kidd (5) have shown that the extent to which a salt is absorbed by a particular tissue depends both on the cation and the anion of the salt. Thus, in experiments with discs of carrot and potato, they found that the absorbtion of NO_3 varied with the cation with which it was associated, decreasing in the order K, Na, Li, Ca, Mg, Al. Raber (6) has shown that the permeability of cells to a given anion decreases with the valency of the cation with which it is combined.

Other materials, potassium permanganate, ammonium sulfate, ferric chloride, and stannic chloride, have been more or less effective in hastening emergence of the sprouts. The results with these materials are complicated by the toxicity of some of them, and they have not yet been tried over a sufficient range of concentrations. The time factor will also receive attention in future tests.

Discussion of Results

The materials which have been effective in stimulating sprouting have the general characteristics of being vigorous oxidizing agents. But ferrous and stannous chlorides, which are reducing agents, have given about the same results as the corresponding ferric and stannic salts. Since both of these salts are very quickly oxidized to the ferric and stannic forms respectively, by exposure to air, it is likely this occurred in treating the potato seed pieces, and the salts then functioned within the tissue as oxidizing agents. Sodium chloride has been shown to be without effect in several tests, and sodium nitrate is comparatively ineffective also.

Accompanying every oxidation, there must be a corresponding reduction. Both processes may be accomplished in plant tissue by enzymatic processes. That potato tuber tissue is abundantly supplied with reductases was shown by Bach (7), who demonstrated the ability of sodium nitrate to oxidize acetic aldehyde in the presence of extract of potato tuber, the nitrate being reduced to nitrite.

That the chemical oxidation of the tissue may be independent of oxygen supply is shown by the results obtained with ferric and stannic chlorides, which are able to stimulate growth, and may do so by their exidative effect within the cells. However, salts which are also carriers of oxygen, such as nitrates, sulfates and permanganates, may be even more effective. In other words, there may be a specific effect of oxygen, aside from the liberation of positive charges through the reduction of a salt or ion absorbed by the potato.

The results of Appleman, who was able to stimulate growth

by methods which introduced oxygen into the tissue, such as treatment with hydrogen peroxide, prevention of suberization of the skin, greening, or by peeling off the skin if it was already suberized, are explainable on the grounds of this theory. Oxygen is an excellent oxidizing agent (in the presence of water, for it is ionized only when it goes into solution) due to its affinity for H ions. Ionized oxygen then removes H ions from some oxidizable material in the tissue thus increasing its positive charge (oxidizes it).

There are other factors, however, which must be kept in mind in studying the effect of a stimulant. There may be changes in cell permeability involved, or changes in H-ion concentration which might influence the hydration of the protoplasm, or the activity of enzymes, or the stimulant may act as a catalyst and speed up the normally slow or leisurely processes by which growth releasal is brought about. Concerning this last point it is interestingt to note that Ray (8) found that the effect of chloroform on the oxidation system of the cell is directly connected with that system, and to be distinct from any effects on permeability. He concludes that its action is chemical in nature, and it either acts by catalysis, or by the formation of a loose compound with some portion of the system.

Respiration

Energy is made available to plants by respiration, whereby reserve materials, carbohydrates or fats, or their derivatives, are broken down with the evolution of carbon dioxide. Respiration is an oxidation process. It has been shown by various workers that the action of various rest-breaking treatments is accompanied by accelerated respiration, as measured by evolution of CO_2. The inference may be drawn that this result is due to the oxidation effect of the stimulant, in the case of salts and of oxygen, and to the catalytic effect on oxidation in the case of anesthetics—ether, chloroform, ethyl bromide.

Two experiments, lasting 10 days each, have been conducted to determine the effect of treatment with 5 mol. $NaNO_3$ and with .001 mol. $FeCl_3$ on respiration of dormant potato seed pieces. With both treatments, there was a sharp increase in CO_2 output in the treated lots as compared to the check lots, indicating that both treatments had accelerated respiration. This acceleration was marked for several days, then gradually declined. This is further evidence that the effect of the rest-breaking agencies used in this work, is due to their oxidizing power.

Changes in Reaction

It was found that the reaction of tissue about the eyes changes toward alkalinity during the dormant period and the apical eyes, which usually grow first, are more alkaline than basal eyes. Newly dug mature White Rose potatoes on September 4 had a pH value of 6.0 at the apical eyes, and of 5.8 at the basal eyes. Other potatoes of the same lot, on November 8, after sprouting had started, had pH value of 6.5 and 6.3 at the apical and basal buds respectively.

Another lot of newly dug and rather immature White Rose tubers on November 8, November 21, and November 28 gave pH

value of 6.0, 6.3 and 6.3 at the apical eyes, and 5.7, 6.0 and 6.1 at basal eyes. The exact significance of this change in reaction during after-ripening has not been determined. It might easily be connected with the activation of oxidizing enzymes. Appleman (9) found that a striking correlation existed between respiration and catalase activity, both of these increasing with any treatment which hastened growth-releasal in dormant potatoes. Correspondingly, Harvey (10) found increased catalase activity with decreased acidity in certain plant galls, while in mosaic-diseased tobacco (11) he found a decrease in catalase with increased acidity.

The salt solutions used for treating potato seed-pieces varied from pH 3.0 in the case of .001 mol. $FeCl_3$ to pH. 7.3 in the case of 0.25 mol. $(NH_4)_2 SO_4$. The latter solution was the only one giving positive results which was on the alkaline side of neutrality, as it happened to have been diluted with tap water (pH 8.0). No connection is as yet apparent between the reaction of the salt solution used and its effect on stimulating growth. A series of treatments with unbuffered solutions made up of HCl and NaOH, ranging from pH. 1.0 to pH. 12.0 has given results of no particular significance, as yet.

Solutions having an acidity below 6.1 about pH become less acid, while solutions above pH 6.1 became more acid when seed-pieces are immersed in them. Thus, a .25 mol. solution of $(NH_4)_2 SO_4$ had a pH of 7.4 before seeds were immersed. After seed pieces had been immersed one-half hour it had changed to pH 7.1, after 1 hour to 6.9, after 2 hours to 6.7, after 3 hours to 6.5. Similarly, the changes in a .0002 mol. solution of $FeCl_3$ were from pH 3.3 to pH 3.7, 4.05, 4.5 and 5.0. The change in reaction was more marked when the seed pieces were not carefully washed after cutting, and were less marked when more concentrated solutions were used. The results are in line with those of Robbins (12) who obtained similar results with thin discs of potato tuber tissue in buffered solutions, and who assumed that the change in reaction was due chiefly to an ampholyte, possibly a protein, whose iso-electric point is in the vicinity of pH 6.0. In this connection, it should be stated that Cohn, Gross, and Johnson (13) found that tuberin, the principal protein in potato, was iso-electric between pH 4.27 and 4.50, while at pH 6.0 , the H-ion concentration found by them in the juice of the potato, the protein bore a negative charge.

Conclusions

Sprouting of dormant potato tubers can be hastened, and the percentage germinating within a more or less limited period, can be increased by dipping the cut seed pieces in 0.5 mol. solution of sodium nitrate. Other oxidizing substances to which the cell is permeable and which are not toxic when used at an appropriate concentration have a similar effect. Because of its general use as a fertilizer, and because the cheap commercial grade (13 pounds to 10 gallons of water) has been found to be as effective as the chemically pure salt, it is believed that sodium nitrate will be the most practical material for use by farmers.

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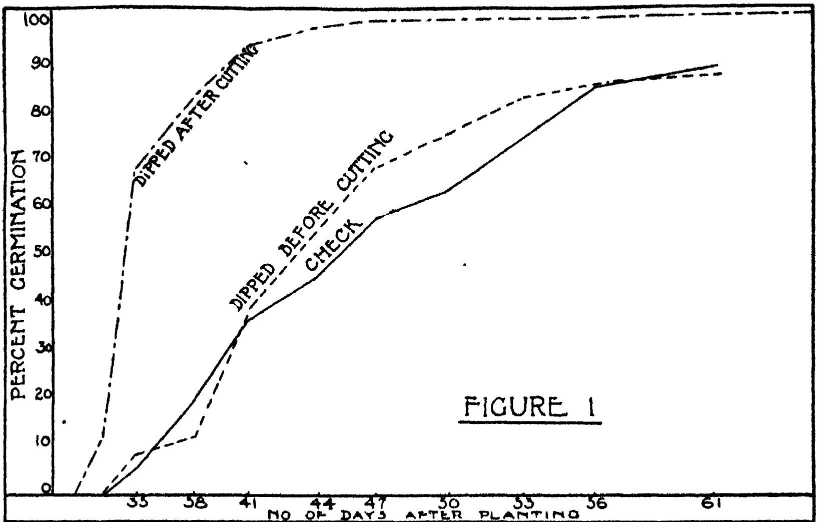

FIGURE 1

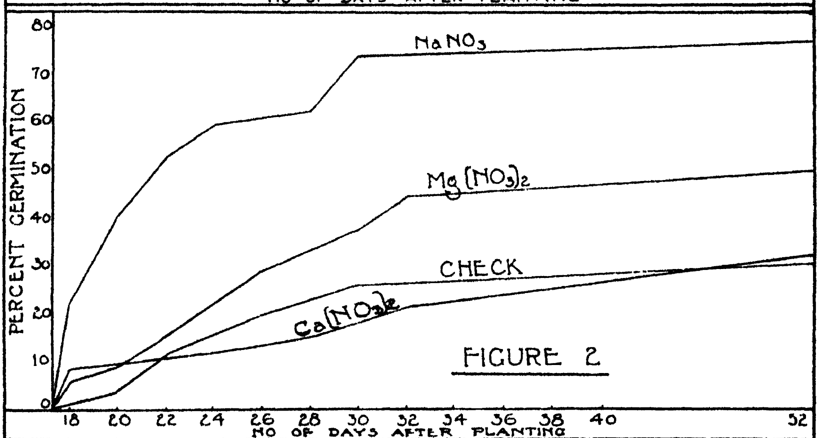

FIGURE 2

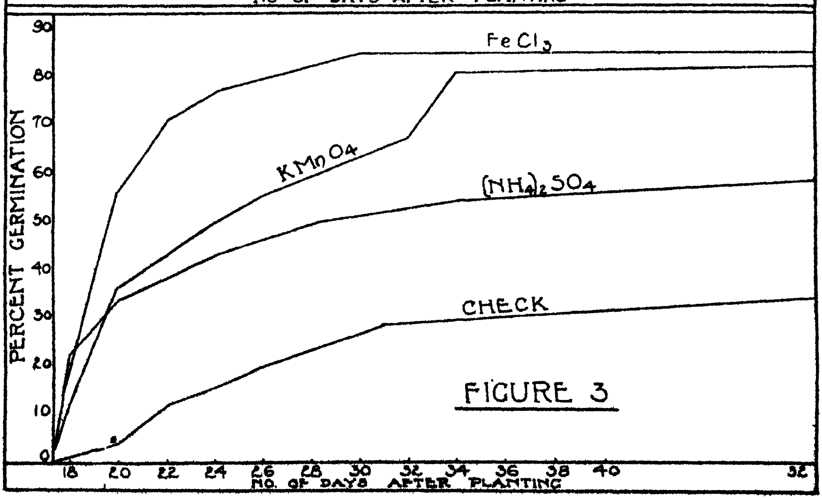

FIGURE 3

The Possible Relation of Anthocyan Pigments to Summer Injury in Potatoes and Sweet Corn

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DIFFERENCES in the amount of tip burn in certain strains of the Rural New Yorker potatoes in another experiment at the Agricultural Experiment Station, called attention to the possibility of this problem. The strains of potatoes came from different sources, but all belong to the same variety. In four of these strains the leaves and stalks were light green, and in eight others they were dark purplish green in color. The difference appears to be in the amount of the purple anthocyan pigment present in the plants.

The dark colored vines contained large quantities of this pigment in the epidermal tissues, while the light colored ones had little or none of it. In the dark colored vines, this purple pigment often could be seen in all parts of the plant above ground, namely stalks, leaves and flowers. In the light colored vines, the leaves and upper part of the stalks were free from it, or sometimes had rather dilute quantities at the base of the stalk near the ground. The differences were so pronounced that the light and dark colored vines could be distinguished as far as the field could be seen and the severity of the tip burn in the purple lots led to the supposition that this trouble might be associated with the presence of the pigment.

The lots were slightly mixed in color for there were a few dark colored plants in the light colored strains and a few light ones in the dark colored strains. In each case these individual plants behaved like the large groups having the same colors. That is, the light colored plants did not tip burn while the dark ones did.

Intermediate types were common and the darker colored ones were affected by tip burn about as badly as those which were the most deeply colored, but they did not develop the trouble as rapidly. These observations strengthened the supposition that the purple pigment might be associated with tip burn.

Since all varieties of potatoes do not have this purple pigment in the same degree, it was of interest to find out how other varieties responded to tip burn. Many early, mid-season, and late varieties, have been studied by other investigators. By analyzing their reports and classifying the varieties they have studied, according to the amount of color in the vines, we find that those having large quantities of purple pigment showed tip burn first and the injury often spread to 100 per cent of the leaves. Those varieties having intermediate amounts of the pigment developed tip burn in 50 per cent to 75 per cent of the leaves and those having little or no pigment usually showed less than 25 per cent of leaf injury.[*]

They also report that tip burn did not occur in the early and mid-season sorts until late in their growth. This has been attributed

in the past to weakening of the plants by old age, which would make them susceptible to injury from any adverse condition. It is also true that it is at this time of the season that climatic conditions tend to become extremely hot and dry and any injury which might come from excessive temperatures would not be expected to appear before that time.

Furthermore, it was observed that tip burn was much more severe during the two seasons of 1921 and 1922 when the climatic conditions during the months of July and August were extremely hot and dry. The air temperatures ran very high during the day and this was accompanied by brilliant sunshine. No rain and, in fact, no very cloudy days occurred during periods of six and eight weeks respectively in these years. Characteristic tip burn showed first late in July and the leaf tissue broke down rapidly during August in the purple stalks, so that by September first the leaves were nearly all dead, and at the end of the season the plants were dry before the first frosts came. In the green type, tip burn did not appear at all during the entire season, except for a trace on an occasional leaf. At the end of the season the green plants were still alive and in a growing condition.

It has been shown by previous investigators that plant tissues having red, blue, or purple colors of anthocyan origin, frequently absorb enough heat from the sun when exposed to extreme conditions that severe injury, or death, to the tissues, may result. It was thought that this might have been the case here and in order to test the temperatures of the potato tissues just described, a thermo-electrical apparatus was set up for the purpose of making these observations. Two sprouts of similar size were selected from green sprouted potatoes of the same variety. One of these sprouts was densely filled with the purple pigment. It was so dense that little of the green chlorophyll could be seen. The other sprout contained only a trace of the purple, but otherwise was normal for the variety. The thermo-couple was inserted in each sprout in turn, placed in the sun and left until the coil came to rest. The deflection caused by the temperature of the purple sprout was 121.5 mm., and the green 60 mm., making a difference of 61.5 mm. When compared with the calibration chart of the galvanometer for temperature the difference was about 20°C. This showed that the purple sprout was about 20°C. warmer than the green sprout. The temperature within the purple sprout was 41.5°C. while that in the green one was 20°C., under laboratory conditions. This was early in June before the excessive temperatures of July and August had arrived.

When the plants in the field became large enough and the season sufficiently far advanced, the climatic conditons became unfavorable for high temperatures. During the months of July and August the sky was clouded most of the time and frequent rains fell. No long continued periods of hot and dry weather occurred. There was no tip burn in the potatoes under observation, and no temperature measurements could be taken which would even approximate the extremes of 1921 and 1922. So the preliminary

observations on potatoes were the best that could be obtained this season.

In connection with a larger experiment in sweet corn improvement, certain selfed strains of the Stowell Evergreen variety segregated into types which varied in quantity of the anthocyan pigment from densely colored stalks, through various intermediate types to pure green. Those called pure green did not show any purple or red color in any part of the plant at any stage of their development, while those having the purple color densely impregnated contained the pigment in all parts except the ear itself.

When these types were planted in the field in 1921, they all started to grow normally and continued to do so until the temperatures began to run very high and a period of six weeks followed without rain during which time the sun was very brilliant, and the temperatures became extremely high. At this time the purple stalks stopped growing and had difficulty in maintaining themselves. The older leaves at the base of the stalks dried up and the plants produced only rudimentary tassels and no ears. They showed distinct signs of firing and other evidences of drought injury. The green types in immediately adjacent rows continued to grow and produced normal tassels and ears. This condition was reproduced in 1922 during a period of drought which lasted eight weeks and was even more pronounced. Many purple plants were killed outright. Intermediate types having large amounts of the purple pigment tended to respond to the hot, dry weather, in a manner similar to the densely impregnated ones, but the injury was less. Some of the first leaves died somewhat earlier than usual, but the stalks formed normal tassels and ears.

These observations brought up the same question of a possible relation between the purple color and the injury to the plants bearing it under the adverse climatic conditions that were mentioned above. To find out something about the ability of the purple parts of the corn plant to absorb heat, seed of both the densely purple colored and pure green types were planted in pots in the greenhouse where they were grown until near tasseling time. Then on July 25, 1923, they were set out in the open and the temperatures taken by the same set of instruments mentioned above. The sky was partly covered with white fleecy clouds and a cool breeze was blowing which caused the temperature in the plants to fluctuate through a range of several degrees. The temperatures in the tissues were recorded at such times when the wind died down and the sun shown brightly for a period of time long enough for the tissues to heat up and the galvanometer to register them. The air temperature was 85°F. The temperature in the purple stalk was 90.2°F., or 5.1° above that of the surrounding air. The temperature in the green stalk was 83.9°F., or 1.2° below that of the surrounding air. There was a total of 6.3° difference in temperature between the purple and green stalks under the existing conditions. They were by no means as severe as those which are common in the field under droughty conditions in midsummer. It was unfortunate for this experiment that similar extreme climatic conditions as those of 1921 and 1922 did not occur in 1923 for it is suspected that much higher

temperatures occur in the purple plants of both potatoes and sweet corn under field conditions than those observed, and that the differences in temperatures between the purple and green plants are much greater.

A portable set of instruments has been assembled with which the actual temperatures of plants can be taken under field conditions. This study will be continued in 1924 and physiological studies in connection with catalase and oxadase activities will be undertaken in order to observe the nature of the plant's internal response to higher temperatures.

Pollination and Self-Fertility in the Onion

By H. A. JONES, *University of California, Davis, Calif.*

BREEDING work was begun at the University Farm in 1923 with the hope of isolating in time more uniform strains of the standard commercial varieties of onions.

California is an ideal place to conduct this work because of especially favorable climatic conditions. The two most extensive onion seed producing regions of the United States are located in the Sacramento and San Joaquin River delta, and in the Santa Clara Valley of Central California. In these areas the atmospheric conditions during May and June when the onions are in bloom are very favorable for pollination and seed setting. At the University Farm, located in the Sacramento valley, during the time of onion pollination and while the seed is maturing, the relative humidity is low throughout the 24 hours, the days are clear and there is no dew at night. While the aim is to develop improved strains of onions, the main problem in 1923 was to develop pollination technique whereby a large number of plants could be selfed without a great expenditure of labor.

On December 22, 1922, mother bulbs of the following varieties were planted in the field, Yellow Danvers Flat, Southport Yellow Globe, Southport White Globe, Southport Red Globe, Sweet Spanish, White Portugal, Australian Brown, Prizetaker and Red Wethersfield. All varieties were selfed, but most of the pollination studies were made with the Australian Brown. The first flower stalks in the latter variety were found in dissected bulbs February 22, 1923. In similar studies (2) at College Park, Maryland, developing flower axes in Yellow Globe Danvers were first observed the latter part of March. At Davis, three plants with good top growth were pulled and dissected on March 2, each branch of the different plants as shown in Table 1, had an elongating flower axis.

TABLE 1.

Length of Sprouts and Floral Axes. March 2, 1923. Australian Brown

Plant Number	*Branch length in cm.*	*Length of flower axes in mm.*
1	34	8.0
2	26	3.0
.	26	2.0
.	25	2.0
3	30	2.0
.	28	1.5
.	25	2.0

The first appearance of seed stalks through the surrounding sheaths in Australian Brown was on March 26. Yellow Danvers Flat, however, had flower stalks visible as early as March 5. Australian Brown starts into growth somewhat later than Yellow Danvers Flat due to its prolonged dormant period.

FLOWER BEHAVIOR

The first Australian Brown flowers opened May 15. When the perianth of the flower first expands the anthers are still immature. The anthers of the three inner stamens are the first to dehisc. They shed their pollen one after the other at irregular intervals. After the inner whorl of stamens has shed its pollen, the anthers of the outer whorl of stamens dehisc, also at irregular intervals. The above order of dehiscence is the rule, but occasionally one or more anthers of the outer whorl discharges pollen before the inner start to shed. All pollen of any one flower is shed before the stigma becomes receptive. The style is approximately 1 mm. long when the flower first opens. It continues to elongate, but does not reach its maximum length of about 5 mm. until some time after all pollen has been shed. All flowers of the inflorescence do not open at one time. Anthesis may extend over a period of two weeks or longer.

For a detailed study of anther dehiscence 50 flowers on as many different plants were labeled at 4:00 P. M. on June 2, 1923. Only those flowers were selected that had the perianth fully expanded and the pollen unshed. Dehisced anthers were counted at intervals starting 7:00 A. M. the following day. Results of these studies are given in Table 2.

Most of the pollen was shed between 9:30 A. M. and 5:00 P. M. Under atmospheric conditions existing during the period of these observations, it was 23 hours after labeling before any flower had all its anthers dehisced and 47 hours before all anthers (except one) under observation had shed their pollen. Because of the protandrous habit of the onion flower, autogamy does not occur, but geitenogamy no doubt is of frequent occurrence even in open pollinated plants.

In the field the chief agencies of pollination are various species of insects. These go from flower to flower on the same inflorescence, visiting the nectaries which lie in the axils of the three inner stamens, and at the same time carry pollen from flower to flower.

TABLE 2
Rate of Dehiscence of Anthers of 50 Flowers of Australian Brown, 1923.

Time of Observation	Total number of anthers shed	Flowers with all anthers shed	Temperature in degrees Centigrade
4:00 P. M. June 2	0	0	....
7:00 A. M. " 3	20	0	19.0
8:00 A. M. " 3	22	0	21.9
9:00 A. M. " 3	23	0	25.6
10:00 A. M. " 3	54	0	27.1
11:00 A. M. " 3	93	0	30.5
12:00 Noon " 3	136	0	31.0
1:00 P. M. " 3	150	0	32.5
2:00 P. M. " 3	167	0	32.7
3:00 P. M. " 3	190	4	32.8
4:00 P. M. " 3	223	9	32.5
5:00 P. M. " 3	238	17	29.5
6:00 P. M. " 3	245	19	27.0
7:00 P. M. " 3	247	20	24.0
7:00 A. M. " 4	248	20	18.0
8:00 A. M. " 4	248	20	20.9
9:00 A. M. " 4	248	20	22.9
10:00 A. M. " 4	249	21	22.5
11:00 A. M. " 4	256	23	25.4
2:00 P. M. " 4	295	45	28.5
3:00 P. M. " 4	299	49	28.5

Hence, it is probable that even in open pollinated plants, considerable selfing takes place in strongly self-compatible varieties, and a heavier yield of seed per acre should be expected from those varieties that are highly self-compatible.

Method of Handling Selfed Plants

When the first open flower of the inflorescence had the perianth fully expanded and before the anthers had begun to dehisc, the entire umbel was enclosed within a one or two pound Manila paper bag. The size of the flower head determined the size of the bag to be used. Whenever possible, the smaller bags were used, because they exposed less area to the wind. This is important in a region like the Sacramento Valley where strong winds are prevalent during onion blooming time. Labeling, such as date, series, and plant number, can be done directly upon the bag. The bag was tied securely about the flower stalk below the flower head in order to keep out insects and prevent loss of seed when the capsules dehisc.

The field was gone over twice each day, once before noon and again late in the afternoon, additional flower heads were bagged and those already enclosed were tapped vigorously with the hand. At the time of the second, or afternoon, pollination, most of the pollen for that day has been shed, it is dry and scatters readily. It is doubtful if this method of self-pollination can be used so effectively in regions where rains are prevalent, or where the relative humidity of the atmosphere is high. According to Crow (1) at Guelph, Canada, their choicest onion stocks are grown under glass and self-pollinated by hand. By following the method described here, one individual can successfully pollinate several thousand

flower-heads twice each day. The seed heads are usually ready to be harvested about two months after bagging. When seed is mature the stalk is cut two or three inches below the bag and the seed is allowed to remain in the same container until threshing time. After harvest the bags are laid on canvas, or in shallow trays, in the sun and allowed to dry. It is best not to delay threshing of the individual heads for too long a time. The pericarp surrounding the seed is very hygroscopic and when the weather becomes damp in late fall and winter threshing becomes increasing difficult. When dry the seed head is emptied into a small cloth sack, rubbed between the hands until seeds are free, then the entire content is poured into a beaker of water. When stirred the heavy seeds sink and the chaff and light seeds can be floated off.

Results of Self-pollinating Yellow Danvers Flat

In Table 3 are given yields of seed obtained from seven different self-pollinated plants of Yellow Danvers Flat. These were selected to show the different degrees of self-compatability.

TABLE 3

Date of Bagging (Date First Flower Opened) Each Inflorescence, Yield of Seed Per Head and Total Yield of Seed Per Plant. Yellow Danvers Flat.

Plant number	Inflorescence bagged		Number of seeds
26	May	5	13
"	"	20	1
"	"	21	3
"	"	27	5
"	June	3	4
Total			26
Average number per head			5.2
9	May	14	78
"	"	15	51
"	"	15	30
"	"	17	68
"	"	19	27
"	"	25	17
"	"	29	35
"	June	3	10
Total			316
Average number per head			39.5
4	May	15	102
"	"	15	57
"	"	18	73
"	"	18	58
"	"	19	85
"	"	21	34
"	"	26	52
"	"	28	18
"	June	3	22
Total			501
Average number per head			55.7
33	May	23	92
"	"	25	69
"	"	28	115
"	"	29	62
33	May	29	27
"	"	30	61
"	"	30	63
"	June	2	63
"	"	3	100
"	"	4	12
Total			664
Average number per head			66.4
13	May	21	243
"	"	21	211
"	"	22	277
"	"	23	191
"	"	24	140
Total			1062
Average number per head			212.3
22	May	13	490
"	"	14	424
"	"	15	309
"	"	17	404
"	"	17	302
"	"	20	389
"	"	26	394
"	"	28	100
Total			2812
Average number per head			351.5
24	May	15	531
"	"	18	561
"	"	18	958
"	"	22	880
Total			2930
Average number per head			732.5

Within certain limits the same degree of self-compatability holds true for all the different inflorescences of the entire plant. Though the figures show a considerable variation in *number of seeds* produced on the different umbels of the same plant, the same variation in *degree* of self-compatability does not exist for there is a marked difference in the number of flowers in the different inflorescences. In the work this coming season it is planned to express the degree of self-compatability among the different umbels of the same plant as per cent of a perfect set. As a rule the more perfect the set the greater is the self-compatability.

There appears in most plants to be a lighter set in the later blooming umbels. The majority of plants of Yellow Danvers Flat are highly self fertile, as can be seen by referring to Table 4.

TABLE 4

Yield of Seed Obtained From Selfed Plants and Average Yield Per Head, Yellow Danvers Flat.

Plant number:	Seed heads: per plant:	Seed yield: per plant:	Seed per head: Average number:	Plant number:	Seed heads: per plant:	Seed yield: per plant:	Seed per head: Average number:
1	14	1097	78.4	18	6	333	55.6
2	8	1275	159.4	20	9	2266	251.8
3	4	239	59.8	21	8	656	84.0
4	9	501	55.7	22	8	2812	351.5
5	4	409	102.2	23	6	1400	233.3
6	7	1192	170.3	24	4	2930	732.5
7	9	554	61.6	25	4	589	147.2
8	10	947	94.7	26	5	26	5.2
9	8	316	39.5	27	8	2791	348.8
10	6	2654	442.3	28	5	1020	204.0
11	5	26	5.2	29	4	1080	270.0
13	5	1062	212.3	30	5	1085	217.0
14	7	1831	261.6	31	6	1156	192.7
15	12	1558	129.8	32	2	232	116.0
16	5	1307	261.4	33	10	664	66.4
17	5	2007	401.4				
Total					208	36,015	
Average number of seed per plant						1,161.8	

Averaging the above 31 individuals a yield of 1161.8 seeds per plant is obtained. The average number of seed stalks per plant is 6.7, and the average number of seeds harvested for each seed head is 173.1. All the flower heads of this variety were bagged so it is impossible in this case to compare selfed with open pollinated plants.

The above variety, however, is one of the heaviest seeders under open pollinated field conditions. Morse (3) states "The heaviest crop I ever knew was 1500 pounds per acre of Australian Brown and 1400 pounds of Yellow Danvers Flat. Out of a total of several hundred acres of onion seed, there are always some pieces that are total failures and many that scarcely pay to cut. However, acre for acre and covering a period of many years, we figure that a fair average is 300 pounds per acre for red varieties, 400 pounds for

yellow and brown, and 200 pounds for white." The yellow and brown varieties are the heaviest producers.

Efficiency of Wind in the Pollinizing of Bagged Heads

A number of flower heads of Australian Brown were bagged on May 25 and 26. These were not tapped by hand, but were shaken by the wind only. That fair sets of seed were obtained can be seen by referring to Table 5.

TABLE 5

Yield of Seed From Flower Heads That Were Bagged and Shaken by Wind Only, also Open Pollinated Flower Heads of the Same Plant, Australian Brown

Plant number	Date bagged	Number heads bagged	Number of seed	Number of open pollinated heads	Number of seed
1	May 25	1	56	4	2084
2	" 25	1	127	1	442
3	" 26	1	540	0	....
4	" 25	2	297	3	1751
5	" 25	1	118	3	3766
6	" 25	1	146	3	1677
7	" 25	1	134	0	....
8	" 25	1	29	3	1452
9	" 25	1	119	0	....
Total	....	10	1566	17	11,172
Average number per head		..	156.6	..	657

That the wind is a very effective agent in facilitating pollination within the bag can be seen by comparing the yield of seed of bagged heads shaken by the wind with flower heads that were bagged and held stationary by tying to wooden stakes.

TABLE 6

Seed Set in Flower Heads Held Stationary. Australian Brown.

Plant number	Number heads bagged	Date bagged	Number of seed	Number of open pollinated heads	Number of seed
1	3	June 4	185	0	0
2	2	" 4	116	3	1947
3	2	" 4	114	2	2634
4	1	" 4	15	2	1328
Total	8	......	430	7	5909
Average number per head		......	53.7	..	844

Table 6 shows that there is considerably less seed set when the flower head is not shaken by hand, or allowed to move freely in the wind. Pollination by gravity may predominate in this case. Thrips were also found in large numbers on the flower heads within the bags. It is not known if these play any role in aiding self-pollination.

Several tests were made to determine if thrips carried foreign

pollen to the bagged flowers. It is almost impossible to prevent thrips from traveling in and out of the bag even though it is tied very securely.

Several Australian Brown flower heads were bagged on June 8. Once or twice each day the bags were removed and all open flowers emasculated. All unopened flower buds were removed on June 10 and 11.

TABLE 7

Emasculated Flowers to Determine Extent of Thrips Pollinated, Australian Brown

Inflorescence	Covered with	Number of emasculated flowers	Date of harvest	Number of seed set
I	Cloth sack	139	July 29	0
K	Paper sack	49	July 29	0
U	Paper sack	105	July 29	0
V	Paper sack	?	July 29	0
X	Paper sack	?	July 29	0

These results show that there is very little or no danger of cross pollination by thrips carrying foreign pollen into the bag during the period of pollination.

SUMMARY

Bagging the onion inflorescence with one or two pound Manila paper bags and then shaking by hand twice each day, is a very efficient method of self-pollination. This method may not be so conducive of good results where rains and heavy dews are prevalent, or where the relative humidity is especially high.

Flower heads that were bagged and shaken by the wind only, gave a very good set of seed when compared with plants that had the bagged heads tapped by hand. The relative efficiency of the former method will no doubt vary from year to year depending upon the amount of wind experienced during the onion pollination season.

A light set of seed was obtained from heads that were not shaken by hand, or by wind, but were held stationary by tying to stakes.

Most of the self-pollinized plants show a high degree of self-compatability. There does exist, however, in different plants, every degree from feeble to strong self-compatability. Within certain limits the same degree of self-compatability holds for all flower heads of the same plant. An attempt will be made to isolate uniform strains of the standard commercial varieties of onions that are also highly self-compatible.

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Pollination Studies With Greenhouse Tomatoes

By H. W. Schneck, *Cornell University, Ithaca, N. Y.*

WITH the rapid growth of the greenhouse vegetable industry, and with increased production of winter lettuce in the South and Southwest, many vegetable greenhouse men have found that tomatoes offer better returns than lettuce in fall and early spring. But the general complaint among greenhouse tomato growers has been that the yields secured are much lower at these times than in late spring.

In surveys which were made in different vegetable forcing centers, it was found that these men pay little attention to the matter of pollination, and that seldom is this question considered important enough to give it more attention in fall and early spring than in late spring when the days are longer and much more sunshine prevails under which conditions more pollen forms. As a result of these surveys it was felt by the writer that low yields might be due to lack of proper pollination of the tomato blossoms.

Object of Experiment

In order to throw definite light upon this problem, an experiment was planned and conducted during the late winter and early spring of two consecutive years, 1920 and 1921. The object of this experiment was to determine the effect of various methods of pollination upon the following factors with five of the most important greenhouse tomato varieties separately and collectively:

Set of fruit	Grade of fruit
Yield	Blossom-end rot
Earliness	Cost of production
Size of fruit	Net returns
Shape of fruit	

Many writers recommend and emphasize the importance of some method of artificial pollination of tomatoes when forced in the greenhouse, in order to secure a satisfactory set and development of fruit, but none of these writers, with the exception of Bouquet (1919) of the Oregon Agricultural Experiment Station, and Fletcher and Gregg (1907) of the Michigan Agricultural Experiment Station, give much, if any, experimental data, to show the effects of different methods of pollination. Recommendations made are based largely upon observation.

Bouquet (1919) gives results of extensive trials made in commercial greenhouses of Oregon and at the Oregon Agricultural Experiment Station, comparing set of fruit and yields of hand pollinated with jarred and untreated plants. As a result of these investigations, he recommends the emasculation method of pollination for greenhouse tomatoes.

Fletcher and Gregg (1907) have shown that size and shape of tomato fruits are largely dependent upon the amount of pollen applied to the stigmatic surface of the pistil, the more pollen, up to

a certain amount, that is applied, and the more uniformly it is distributed over the stigmatic surface, the larger and smoother will be the resulting fruit.

Method of Pollination

The following methods of pollination were used as representative of all the distinct methods of pollination: emasculation, watch glass, camel's hair brush, jarring, and untreated plants referred to as checks. The camel's hair brush method was used only one year.

The emasculation method consists in collecting pollen from fully opened flowers on the thumb nail of the left hand, and applying it to the stigmatic surface of the pistil of flowers after the corolla and stamens have been removed. These can easily be removed from flowers that have been fully open, when the petals begin to close and shrivel, by grasping the tips of the petals with fingers of the left hand and pulling straight out, holding the flower with the right hand. As the stamens are attached to the petals, both are removed in one operation, leaving the pistil with the stigma exposed.

The watch glass method consists in collecting pollen on a watch crystal held in the left hand, and with the right hand the stigma of flowers with petals fully opened and reflexed are gently pressed into contact with the pollen.

The camel's hair brush method has received more attention by greenhouse men than other hand methods, because it is simple and quick. The brush is simply twirled inside the flowers when they are fully opened.

Practically the only method of pollination used by nearly all vegetable forcing men during all seasons and at all stages of growth of the plants, consists in jarring them occasionally, usually once every day. The main stem of each individual plant is shaken sharply twice at each pollination.

Plants referred to as check plants in this report received no artificial pollination. They were disturbed as little as possible, but in caring for and pollinating other plants some slight disturbance probably took place.

The hand pollinated plants were treated 37 times each season and those jarred 74 times. It was planned to jar the plants every day and to hand pollinate every other day.

Planting Arrangement

Entire greenhouses of all iron frame truss construction 25 by 50 feet in size for the 1920 experiment, and 33 by 50 feet for the 1921 experiment, were used. Plants were set in the beds in rows three feet apart and 15 inches apart in the row on January 24 in 1920, and on February 5 in 1921. All the plants were trained to a single stem and they were all headed back at the same time at approximately the same height.

There were 12 rows of plants across the greenhouse included in the experiment each year, and these were divided into three similar groups of plants of four rows in each group, and with one row of each variety in each group. Each group or set was divided

into four divisions in 1920 and five divisions in 1921, for the different methods of pollination, the brush method not being used in 1920. This arrangement provides for a uniform test in that each variety with each method of pollination, was tested in different parts of the greenhouse.

The data given are averages of two years' experiments, each experiment repeated three times, with the total number of plants of each variety for different methods of pollination indicated in Table I.

TABLE I

Number of Plants of Different Varieties Treated with Different Methods of Pollination

Variety	Emasculation	Watch glass	Brush 1921	Jar	Check
John Baer	19	20	10	24	24
Globe	23	20	10	19	23
Bonny Best	20	20	10	19	22
Comet—1921	8	10	11	8	11
Beauty—1920	12	12	..	12	12
Totals of all Varieties	82	82	41	82	92

A row of plants at either end of the greenhouse and the plants at the ends of the rows on either side of the house, were not included in the experiment. These were discarded in order that plants on which records were taken would be exposed to uniform growing conditions of soil, moisture and sunlight. Pollen was collected from these plants not included in the experiment, in order to eliminate other factors which might aid in the pollination of blossoms under experiment.

EFFECT OF METHOD OF POLLINATION ON FRUITFULNESS OR SET OF FRUIT

Separate counts were made of the total number of blossoms and the number that set fruits on the first three flower clusters and on all the clusters on plants of different varieties with different methods of pollination. Records were taken from over 1200 blossoms on the first three clusters with each method, except the brush method, where over 650 blossoms were considered. For the total set of fruit, over 3000 blossoms were considered with each method, except the brush method, where over 1800 blossoms were counted. The results are summarized in Table II.

TABLE II

Per Cent of Fruitfulness and Effect of Method of Pollination on Set of Fruit, Average of all Varieties

Method of Pollination	First three clusters		Entire plants	
	Per cent fruit set	Per cent increase over check plants	Per cent fruit set	Per cent increase over check plants
Emasculation	62.0	159.2	78.7	90.6
Watch glass	60.0	151.5	79.1	91.5
Brush—1921	50.5	100.0	72.35	38.1
Jar	34.5	44.5	54.6	32.8
Check	24.0	0.0	41.3	0.0
Check—1921	(25.0)	.....	(52.4)	....

The influence of careful pollination by emasculation, or watch glass method, is very pronounced in influencing the set of fruit, especially on blossoms that develop close to the ground where the atmosphere is apt to be moist and where there is more shading of the blossoms than is the case with those that develop higher up on the plant.

EFFECT OF METHOD OF POLLINATION ON YIELD

Fruits were harvested an average of twice a week, and were divided into four grades as follows: firsts—all fruits weighing three or more ounces and of perfect shape; seconds—divided into two lots, one containing fruits of perfect shape, but small in size, and the other lot containing fruits irregular in shape; culls—fruits not included in the other two grades; and rots—fruits affected with blossom-end rot. The total yield records include all fruits not affected with blossom-end rot disease. The average total yield in pounds per hundred square feet and per plant with different methods of pollination for all varieties are given in Table III.

TABLE III

Effect of Different Methods of Pollination on Total Yield and Average Total Yield in Pounds per Hundred Square Feet and Per Plant for All Varieties with Different Methods of Pollination

Method of Pollination	Yield (per 100 Square feet) Pounds	Yield per Plant Pounds
Emasculation	123.3	4.62
Watch Glass	126.7	4.75
Brush—1921	94.4	3.54
Jar	102.3	3.83
Check	62.5	2.34

These figures indicate that the total yield was doubled by pollinating with the emasculation and watch glass methods over the yield secured from the check plants, and that it was increased more than 20 per cent over the yield from jarred plants.

EFFECT OF METHOD OF POLLINATION ON EARLINESS

There were much greater differences in the early yield secured during the first four weeks of harvesting than in total yields as is shown in Table IV.

TABLE IV

Effect of Method of Pollination on Earliness and Average Yield Per Hundred Square Feet First Four Weeks of Harvesting with Different Methods of Pollination for all Varieties

Method of Pollination	Yield in pounds per 100 square feet	Per cent of total yield
Emasculation	32.7	26.49
Watch glass	31.3	24.80
Brush—1921	15.65	16.58
Jar	14.1	13.77
Check	6.2	9.88

The yields are increased over 100 per cent during the first four weeks of harvesting in early spring, when the fruits are most valuable, by emasculation and watch glass methods of pollination over other methods.

The brush method produced nearly as many fruits as the emasculation and watch glass method, but the yield in weight was considerably less, showing that the fruits were considerably smaller. This indicates that not enough pollen grains were applied to the pistils with the brush to develop large fruits. This is due to the fact that pollen grains are not liberated and held on the brush, as they are by shaking them out of blossoms onto a watch glass or thumb nail.

The difference in yield secured during the last eight weeks of harvesting due to different pollination methods is very slight, ranging from 74 per cent with emasculation and watch glass methods to 90 per cent of the total yield with check plants. As with set of fruit it was found that there is much greater need for careful attention to pollination with the first few clusters of flowers on the plants, than with clusters that develop higher up on the plant and later in the season in spring.

Effect of Method of Pollination on Size of Fruit

The average weight per fruit produced by different methods of pollination is given in Table V.

Table V

Effect of Method of Pollination on Size of Fruit and Average Weight Per Fruit With All Varieties With Different Methods of Pollination.

Method of Pollination	Average weight per fruit (ounces)
Emasculation	2.59
Watch glass	2.49
Brush—1921	1.92
Jar	2.15
Check	1.75

The increased weight of fruits produced by the emasculation and watch glass methods is due to the greater amount of pollen which is applied to the stigmas of the blossoms with these methods. Although actual counts were not made, it was noticed that considerably more seeds developed in fruits from flowers pollinated with the watch glass and emasculation methods than in those from other methods of pollinating. Size is correlated with amount of pollen applied to the stigmas of the blossoms, the more pollen that reaches the stigmas up to a certain limit, the larger the fruit.

Effect of Method of Pollination on Shape of Fruit

The number of misshapen fruits of all varieties expressed as per cent of the total number of grade 1 and 2 fruits harvested during different periods, with different pollination methods is given in table VI.

TABLE VI

Effect of Method of Pollination on Shape of Fruit as Shown by Per Cent of Total Number of Grade 1 and Grade 2 Fruits Misshapen During Different Harvest Periods from Different Pollination Methods, Average of all Varieties

Method of Pollination	First four weeks of harvest period	Entire harvest period
Emasculation	4.22	6.98
Watch glass	3.76	7.45
Brush—1921	19.00	9.50
Jar	11.20	11.13
Check	23.38	16.63

Any method of pollination such as the watch glass or emasculation methods that insures an ample amount and even distribution of pollen over the stigmatic surface, will cause the development of smooth, uniformly shaped fruits. The effect is more pronounced on the early formed fruits than on those which form later, because early flower clusters that develop close to the ground and are shaded, produce very little pollen and what is formed is not liberated very readily, especially on check, jar, and brush plants. With the other methods one is certain of securing and applying an ample amount of pollen to all parts of the stigmatic surface of the blossoms because it can be seen upon the watch glass, or thumb nail. When only a few pollen grains reach the stigmatic surface and are not uniformly distributed, lop-sided and misshapen small fruits result.

EFFECT OF METHOD OF POLLINATION ON GRADE OF FRUIT

The effect upon the total weight of each grade of fruit produced by different methods of pollination expressed as per cent of the total weight harvested at different periods is given in Table VII.

TABLE VII

Effect of Method of Pollination on Grade of Fruit and Per Cent of Total Weight of Different Grades of Fruit Produced by Different Methods of Pollination at Differents Periods

	Entire harvest period			First four weeks of harvest period		
	Grade 1	Grade 2	Culls	Grade 1	Grade 2	Culls
Emasculation	49.78	33.80	16.42	68.65	24.66	6.70
Watch glass	47.54	36.24	16.22	69.35	25.93	4.72
Brush—1921	38.7	32.97	28.33	46.33	36.10	15.57
Jar	38.53	45.11	16.36	53.55	33.95	12.5
Check	31.14	42.99	25.87	46.60	37.06	16.34

The figures given for the first four weeks represent the percentage of the total weight harvested during the first four weeks.

The method of pollination has a pronounced effect on the type of fruit produced, the more carefully pollen is secured and applied, the greater is the percentage of large sized, uniformly shaped fruits produced. The effect of careful hand pollination in

producing a large percentage of first grade fruit is more pronounced with early maturing fruits than with those which form later in spring.

Effect of Method of Pollination on Blossom-end Rot Disease

The figures given in Table VIII seem to indicate a correlation between the degree to which the flower is manipulated in pollinating and the amount of blossom-end rot disease.

Table VIII

Effect of Method of Pollination of Blossom-End Rot Disease, as Shown by Per Cent of Marketable Fruits Affected with Blossom-End Rot, Average of all Varieties

Method of Pollination	Percentage of blossom-end rot disease
Emasculation	8.3
Watch glass	6.2
Brush—1921	6.4
Jar	6.15
Check	5.4

The amount of difference in per cent of rotted fruits between different methods is not great enough to justify any definite conclusions. Whether or not the disturbance of the floral organs is a factor involved in the cause of blossom-end rot disease in the greenhouse is questionable, but this seems to be indicated. Possibly by disturbing the floral organs, especially the pistil of the flower, the point of connection between the style and the ovary may be slightly mutilated and cause the development of this disease. There is more danger of injuring the pistil of the flower in the emasculation method than in other methods of pollination.

The larger percentage of blossom-end rot with hand methods of pollination may possibly be due to the larger yield, the increased amount of fruit produced on hand pollinated plants making a greater demand upon the moisture supply in the plant, some fruits thus suffering because of lack of water develop blossom-end rot. Plant pathologists are generally agreed that one factor involved in the cause of blossom-end rot disease is moisture supply.

Effect of Method of Pollination on Cost of Production

The main objection raised by greenhouse men to hand pollination is the amount of time and cost required to pollinate by these methods. They do not consider the increase in returns a slight expenditure for extra labor in pollinating may produce. Accurate data were taken on the time required to pollinate with different methods, and the cost was estimated at 35 cents per hour. The entire time required and the average cost of each method per plant are given in Table IX.

TABLE IX

Effect of Method of Pollination on Cost of Production as Shown by Time and Cost Together With Increased Yield Per Plant With Different Methods of Pollination

Method of Pollination	Time per plant (minutes)	Cost per plant (cents)	Total yield per plant (pounds)	Increase in total yield per plant over check plants (pounds)
Emasculation	16.62	9.7	4.62	2.28
Watch glass	12.09	7.05	4.75	2.41
Brush—1921	12.33	7.2	3.54	1.20
Jar	3.82	2.2	3.83	1.49
Check	0.00	0.0	2.34	....

The cost of pollination per pound of fruit produced was 2.1 cents for emasculation, 1.5 cents for watch glass, 2.03 cents for brush, and .0055 cents for jar. When it is considered that greenhouse tomatoes sell for 20 to 30 cents per pound and four or five fruits make a pound, it can be seen that a very small increase in yield would pay for the entire cost of careful pollination.

EFFECT OF METHOD OF POLLINATION ON NET RETURNS

The net value represents the return after deducting the entire cost of pollination for the whole crop and one-third the cost for the crop harvested the first four weeks. The value of different grades harvested the first four weeks was estimated at 40 cents per pound for firsts, 30 cents for seconds, and 20 cents for culls, and for the last eight weeks at 30 cents for firsts, 20 cents for seconds, and 10 cents for culls. These figures correspond to prices secured by growers at different times. The net returns per 100 square feet are given in table X.

TABLE X

Effect of Method of Pollination on Net Returns Per Hundred Square Feet After Deducting Cost of Pollination

Method of Pollination	Emasculation	Watch glass	Brush	Jar	Check
Entire yield ...	$29.47	$30.32	$19.51	$23.54	$13.45
Yield first four weeks	10.97	10.77	4.51	4.60	2.04

The difference in net returns between check plants and watch glass, or emasculation methods, was approximately 120 per cent for the entire yield and over 400 per cent for the first four weeks of harvesting. The brush method is not as efficient in producing returns as the jar method, especially with flowers that develop on clusters above the third.

Careful hand pollination is much more important as a means of increasing the returns with the first flossom clusters that develop on tomato plants than with those which form later.

These experiments show that careful hand pollination of

blossoms is a very important and economical factor in the successful production of greenhouse tomatoes.

Bouquet, A. G. B., Oregon Agr. College Exp. Sta., Bul. 158, 1919.

Fletcher, S. W., and Gregg, O. I., Mich. Agr. Exp. Sta., Special Bul. 39, 1907.

Some Relations of Hardening to Transplanting

By W. E. Loomis, *Cornell University, Ithaca, N. Y.*

THE work covered in this paper is a continuation of that reported at the Boston meetings last year. The purpose of the investigations has been to find some underlying principles on which to base practical recommendations on the transplanting of vegetable plants. Transplanting unfortunately covers and is influenced by a large number of factors which may be morphological, physiological, ecological or any combination of these so that the problem of isolating individual factors has been extremely difficult.

Early in the progress of the work it became evident that the processes known as hardening would have to be carefully considered. Rapidly growing plants show evidences of hardening after any marked check in growth so that hardening following transplanting is inevitable even where the common practice of prehardening is omitted.

Hardening may have one or more of the following results; (1) it may prepare the plant to withstand the unfavorable moisture conditions following transplanting; (2) it may promote the reestablishment of the plant, particularly the formation of new roots; or (3) it may result in permanent changes in the metabolism of the plant producing in varying degrees the injury known as stunting. Of these the third is too broad a subject to be attempted here and this paper will confine itself to the first two considerations.

Effect of Hardening on Transpiration

It is a common observation that plants grown slowly are more likely to remain turgid under conditions favoring rapid water loss than are more tender plants. Rosa found a decreased rate of water loss from hardened plants, both when growing in paraffined pots and when cut and dried in an oven. The writer duplicated the curves given by Rosa by drying hard and tender plants over sulfuric acid. A number of writers have reported reductions in transpiration in connection with the xerophytic adaptations following hardening, although few of their data are directly applicable to the problem at hand.

Transpiration of Hard and Tender Plants

Three experiments, numbers 41, 43 and 44, on the effect of hardening on the transpiration of plants liberally supplied with

water, are given here. Two other experiments gave essentially the same results. In all cases the plants were grown in glazed jars of one gallon capacity to a size comparable with that of plants of the same sort ready for the field. About two weeks after the seedlings were set in the jars, the moisture content of one lot was gradually lowered until the plants stood near the wilting point for several days, before the determination was made. Water was then added to bring all pots to optimum moisture content, the surface of the soil was covered with a mixture of 80 per cent paraffin and 20 per cent vaseline and the loss in weight over a period of eight to 12 hours, ascertained. The plants were then cut and leaf area and green and dry weights obtained. Transpiration is expressed for the entire period as loss per gram green weight or per square inch of leaf area. When it was found that the two methods were closely comparable, transpiration per gram green weight was taken as a standard, and is used in the comparisons.

TABLE I

Transpiration in Pots, Experiment 41*

Transpiration per gram	Tender	Hard, watered four days previously	Hard, watered two days previously	Hard, watered same day
Tomatoes	1.147	1.108	0.884	0.549
Cabbage	0.836	0.990	.....	0.361
Cucumbers	1.265	1.210	1.175	0.630
Transpiration per square inch				
Tomatoes	0.329	.....	.....	0.144
Cabbage	0.306	.....	.....	0.123
Cucumbers	0.471	.....	.....	0.211

*(12 hour run on April 18th—cloudy—Average temperature 67°, average R H 50 per cent.)

TABLE II

Transpiration of Cut Tomato Plants in Potometers, Experiment 43

	Transpiration per gram green weight from 10:00 A. M. to 6:00 P. M.		Transpiration per square inch leaf area	
	Tender	Hard	Tender	Hard
Plants in gh. Temperature 77° R. H. 42 per cent	2.560	1.118	0.628	0.214
Plants in humid chamber Temperature 85° R. H. 85 per cent	0.751	0.542	0.192	0.108

The cut plants show considerable difference in the transpiration ratio of hard and tender plants as measured by green weight and leaf area, but the more normal results from the growing plants show close correlation. Four plants were used in each treatment in these experiments and the probable error is fairly high.

Experiment 41 was repeated on May 29, under more favorable conditions and with 10 plants in each lot. The results are given in Table III.

TABLE III

Transpiration in Pots, Experiment 44
Plants in Greenhouse in Bright Sun. Temperature 78° R. H. 59 Per Cent

	Weight plants		Transpiration per gram	
	Tender	Hard	Tender	Hard
Tomato	62.04	30.3	3.94	3.68
Cabbage	54.80	25.3	4.58	3.25
Cucumber	53.60	22.5	4.60	4.27

These results follow the lines indicated by the work of Harvey and Rosa who found cabbage more easily and thoroughly hardened than such crops as tomatoes and cucumbers.

TRANSPIRATION AFTER TRANSPLANTING

Two experiments, numbers 51 and 52, were conducted to determine the effect of hardening on transpiration following transplanting. For this work 20 plants in five pots were used for each treatment of which 10 were cut at the beginning of the run to determine the initial size of the plants and the remaining 10, two in a pot, were used for the experiment. The plants were grown and hardened as described above. On the evening preceding transplanting, all pots were brought to optimum moisture by a combination of surface and subsurface watering, so that the plants were turgid and the soil moist at the time of transplanting. The pots were then sealed and weighed and transpiration determined from loss in weight. Water was added after each weighing to bring the potometer back to its initial weight. For convenience in making comparisons the two experiments are grouped together in several small tables. Transpiration for the total run, transpiration for the first period, transpiration for the last period, and transpiration per gram of roots during the last period, are of particular interest as showing initial rate of loss, rapidity of recovery, and the importance of new root growth. (Table IV.)

In every instance the hard, transplanted plants transpired more per gram green weight than did the tender and the difference is greater in the shorter periods, indicating a quicker recovery for the hard plants.

TABLE IV

*Transpiration in First Period**

Crop	Experiment Number	Check		Transplanted	
		Tender	Hard	Tender	Hard
Lettuce	51	4.71	5.34	0.55	0.43
	52	3.61	3.99	0.67	0.84
Tomato	51	6.46	7.45	1.00	1.20
	52	3.21	0.90	0.63	0.74
Cabbage	51	2.83	4.69	0.86	0.30
	52	2.35	4.73	0.50	1.35
Cucumber	51	5.67	6.06	0.48	0.12
	52	7.70	7.18	0.09	0.00

*Loss for first two days calculated on basis of initial weight.

TABLE V

Total Loss from Hard and Tender Plants, Experiments 51 and 52*

Crop	Check		Transplanted	
	Tender	Hard	Tender	Hard
Experiment number 52, duration 8 days				
Lettuce	13.43	14.57	3.55	6.41
Tomato	11.32	9.93	3.26	5.26
Cabbage	10.93	13.35	2.87	5.77
Cucumber	27.50	39.47	1.75	3.86
Number 51, duration 12 days				
Lettuce	30.30	29.50	13.03	16.97
Tomato	39.80	35.03	18.31	21.70
Cabbage	23.60	28.33	12.40	16.38
Cucumber	29.40	36.70	15.46	16.38

*Size of plants taken as average for period.

This table shows a rather unexpected tendency for the hard plants to transpire more after transplanting than the tender. In the case of the check plants the situation is complicated somewhat by growth between the time the plants were measured and the transpiration determined. Since, however, the hard plants were fully expanded and turgid when the weights were taken, and measurements made at the end of 24 hours give essentially the same proportions as those of the table, some other factor must be involved. A shorter period of stomate closure during the night might account for the differences obtained when the transpiration of hard and tender plants is determined under the conditions of these two series of experiments.

TABLE VI

*Transpiration During Last Period**

	Check		Transplanted	
	Tender	Hard	Tender	Hard
Experiment number 52, 6-8 days				
Lettuce	3.10	3.37	1.57	2.67
Tomato	2.51	2.60	1.41	2.43
Cabbage	2.65	2.90	1.10	2.27
Cucumber	6.22	7.42	1.02	1.98
Experiment number 51, 10-12 days				
Lettuce	4.53	6.00	6.08	5.46
Tomato	6.04	5.60	4.55	5.33
Cabbage	3.79	3.83	3.78	3.89
Cucumber	3.10	4.26	3.51	3.84

*Loss between 10th and 12th days for Experiment 51 and 6th and 8th days for Experiment 52.

This table is of especial interest as showing the considerably higher rate of transpiration of the hard plants in experiment 52 one week after transplanting; roughly double that of the tender plants.

Table VII shows the relation between roots and tops in the transplanted plants of experiment 52 and of each to the transpiration of the last two days (6-8).

TABLE VII

Transpiration Per Gram Tops and Per Gram Roots for Last Period, Experiment 52

All plants transplanted

	Transpiration per gram tops		Ratio—Roots×100 / tops		Transpiration per gram roots	
Crop	Tender	Hard	Tender	Hard	Tender	Hard
Lettuce ..	1.57	2.67	5.18	9.71	28.00	27.53
Tomato	1.41	2.43	9.72	12.35	14.57	19.68
Cabbage ...	1.10	2.27	4.78	7.10	22.95	32.00
Cucumber .	1.02	1.98	3.74	7.90	27.80	25.08

There is evidently a closer relation between total root growth and transpiration than between top and transpiration in the days immediately following transplanting. The two crops, tomatoes and cabbage, may be passing the point where mass of roots is a limiting factor so that the correlation between weight of roots and transpiration is less marked with them.

ROOT REPLACEMENT AFTER TRANSPLANTING

The consistently more rapid recovery of the hardened plants in these experiments and the indications that some factor other than reduced transpiration was concerned, led to a study of the rate of root replacement in transplanted plants and the relation of hardening to this replacement.

Plants were grown as before in gallon jars, two plants in a pot, and hardened by withholding water. Water was applied to all pots the evening before transplanting to bring to optimum moisture. One lot of 10 each of hard and tender plants was cut as a check and the others were transplanted into fresh soil, watered somewhat above optimum and returned to the greenhouse for subsequent observations. The check plants were taken up in the same manner as the others; the adhering ball of earth trimmed to a uniform size of about 2½ inches in diameter, and the weight of tops and washed roots determined separately. The roots remaining in the pot were then carefully washed out, dried between blotter papers and weighed. From these it was possible to obtain the normal ratio of the plants at the beginning of the experiment; the ratio after transplanting and the percentage of roots retained by the transplanted plants. The term ratio as used in this paper refers to the relation between weight of roots and weight of tops. The fresh weight of roots is expressed as a percentage of the weight of tops. In the first experiment, observations were made one and two weeks after transplanting, but these periods were found to be too long. In the second experiment the transplanted plants were taken up at intervals of three days and samples of the tops were preserved for analysis at each stage. Table VIII and Table IX.

A study of these tables reveals several interesting relations. As would be expected, the ratio of roots to tops in the check is generally higher for the hard plants. There is, however, a well defined tendency for the tender plants to show a higher ratio at three days. A considerable portion of this is due to the greater loss in

TABLE VIII

Root Replacement by Hard and Tender Plants, Experiment 71

Crop	Tender				Hard			
	Check	as transplanted	7 days	14 days	Check	as transplanted	7 days	14 days
Tomato growth in per cent	.....	.....	65.10	177.50	.....	.....	96.30	404.00
Weight tops	15.20	15.20	25.10	40.90	5.91	5.91	11.60	29.80
Weight roots	3.39	1.92	7.61	8.66	1.57	0.72	4.06	6.85
Ratio	22.10	12.60	30.20	21.20	26.70	12.40	34.80	23.00
Cabbage growth in per cent	.....	.....	—15.90	74.80	.....	.....	—21.00	126.80
Weight tops	19.50	19.50	16.40	34.12	9.84	9.84	7.78	22.30
Weight roots	2.36	1.08	2.18	3.72	1.80	0.54	0.71	2.73
Ratio	12.30	5.59	13.12	10.84	18.40	5.51	8.89	12.38
Cucumber growth in per cent	.....	.....	72.40	177.00	.....	.....	97.50	196.80
Weight tops	15.90	15.90	27.40	43.10	4.62	4.62	9.12	13.70
Weight roots	3.41	2.36	6.06	10.00	1.15	0.94	2.10	4.04
Ratio	21.00	14.90	21.80	23.00	25.00	20.30	23.00	29.80

TABLE IX

Root Replacement by Hard and Tender Plants, Experiment 72

	Tender					Hard				
			After					After		
	Check	As transplanted	3 days	6 days	9 days	Check	As transplanted	3 days	6 days	9 days
Tomatoes growth in per cent	.....	.....	—4.57	—9.50	49.10	.....	.....	5.26	20.50	94.10
Weight tops	55.80	55.80	53.30	50.50	83.20	22.80	22.80	24.00	27.47	44.27
Weight roots	5.82	2.67	3.25	3.79	13.59	2.66	0.99	1.19	2.00	9.37
Ratio	10.40	4.76	6.11	7.51	16.36	11.66	4.29	4.92	7.31	21.18
Cabbage growth in per cent	.....	.....	23.40	33.50	99.80	.....	.....	—2.90	17.10	113.80
Weight tops	44.92	44.92	55.42	59.00	89.76	23.14	23.14	22.45	27.09	49.49
Weight roots	2.67	1.08	1.65	2.23	10.31	2.03	0.58	0.91	1.73	5.46
Ratio	5.93	2.40	2.97	3.82	11.45	8.73	2.52	4.05	6.37	11.90
Cucumbers growth in per cent	.....	.....	—18.90	—24.20	—14.90	.....	.....	—9.30	—5.20	17.60
Weight tops	60.68	60.68	49.20	45.97	51.61	28.18	28.18	25.56	26.72	33.15
Weight roots	10.07	1.86	2.27	3.55	5.37	3.24	0.47	0.44	1.52	4.93
Ratio	16.61	3.06	4.58	7.73	10.35	11.47	1.69	1.72	5.70	15.01

top weight for the tender plants because of greater wilting. The hard plants start growth sooner and their growth curve plotted on a percentage basis rises more rapidly. This recovery is accompanied by a more rapid root replacement.

Carbohydrate Relations in Transplanted Plants

Something of the relative carbohydrate changes involved in recovery from transplanting is given in Table X. The plants were taken from experiment 72 and the ratios are those of that experiment. Total carbohydrates were obtained by the use of taka-diastase and the term includes sugars and starch, but no soluble pectins, pentosans or other polysacchrids.

The rapid rise in the total carbohydrate content of the tender cabbage plants and the uniformly low content of the difficult transplanted cucumbers are of especial interest in this table. The tender tomato plants were large for the pots and had apparently been checked until their carbohydrate content was only slightly below that of the hard plants. The rapid accummulation of sugars and starch in such easily transplanted plants as cabbage and tomato may explain why these vegetables do not show a more marked benefit from the carbohydrates present in hardened plants. A relation between total carbohydrate content of the top and root formation is indicated.

Discussion

The data given in the first three tables indicate a reduction in transpiration for hardened plants even when liberally supplied with water. Such a result would be generally predicted and might be due to a number of factors such as increased cutinization and bloom, or a thicker leaf with more closely arranged cells preventing a rapid diffusion of water from the intercellular spaces. Water may also be more strongly retained by the hardened cells because of colloidal changes, or changes in the permeability of the plasma membrane to water. To show an apparent decrease in transpiration the hard plants will have to overcome the tendency of their relatively larger root system to promote water loss. Incipient wilting with its rapid check on further transpiration, will also occur less easily in the more rigid tissues of the hard plants.

It is not clear just why the check plants from the transplanting experiments should very largely give a higher transpiration rate for the hard plants, although growth of the plants after the area was taken has been suggested and rapid metabolic changes as well as wider and more continuous stomatal opening may be factors. These results should partially neutralize the first and when it is considered that the transpiration rate following transplanting is frequently considerably higher in the hard plants, the data given here do not justify a stand which supposes any marked benefit from hardening, because of the reduction in transpiration of the hardened plants. Resistance to mechanical injuries and to death by sudden drying may, however, be important under field conditions. If we distinguish between normal transpiration as evaporation from the moist surface of turgid cells and drying as the extraction of

TABLE X

Carbohydrate Relations in Transplanted Plants

Plant and Treatment	Lot	Per cent Dry Matter	Per cent Nitrogen	Total carbohydrates expressed as dextrose		Green weight Roots/Tops x 100
				dry basis	wet basis	
Tender Tomato	Check	11.30	4.49	10.79	1.22	10.40
	3 day	12.40	4.02	12.46	1.55	6.11
	6 day	11.25	4.44	5.61	0.63	7.51
	9 day	9.40	4.73	2.94	0.28	16.36
Hard Tomato	Check	13.30	4.23	10.50	1.40	11.66
	3 day	12.25	3.89	13.70	1.68	4.92
	6 day	11.70	4.10	7.62	0.89	7.31
	9 day	9.47	4.40	2.79	0.26	21.18
Tender Cabbage ...	Check	7.80	5.34	1.23	0.097	5.93
	3 day	10.40	4.56	7.07	0.74	2.97
	6 day	10.10	4.77	3.08	0.31	3.82
	9 day	8.50	5.03	2.83	0.24	11.45
Hard Cabbage	Check	11.90	4.53	6.66	0.79	8.73
	3 day	13.50	4.38	7.40	1.00	4.05
	6 day	10.95	4.76	3.43	0.38	6.37
	9 day	9.20	5.37	2.10	0.19	11.19
Tender Cucumber ..	Check	9.00	4.47	2.99	0.27	16.61
	3 day	11.60	4.75	3.07	0.36	4.58
	6 day	10.75	5.06	1.84	0.20	7.73
	9 day	9.75	4.94	2.35	0.23	10.35
Hard Cuumber	Check	10.00	4.60	3.81	0.38	11.47
	3 day	10.50	4.49	3.46	0.36	1.72
	6 day	10.20	4.71	2.43	0.25	5.70
	9 day	10.10	4.75	2.59	0.26	15.01

water from the protoplasm of wilting cells, it would seem that hardening should reduce to a minimum the latter, highly injurious process.

The evidence in favor of a beneficial effect from hardening through the more rapid reestablishment of the root system of the plant, presumably through the use of food accumulated in hardening, would seem to be more favorable, although here, too, there is considerable conflict. It is not probable that the severity of hardening generally given in practice is necessary to obtain maximum benefit from this source, as the plants have been shown to build up reserves very rapidly and a few days, or, at the most, a week of moderate hardening should be sufficient. Such a short hardening period will also prevent a serious check in growth and will provide larger plants for the field with the same use of artificial protection. While hardened plants grow more rapidly then tender when well supplied with water, they may easily be less than half the size of tender plants of the same age when ready for the field. An appreciable portion of this difference is likely to be retained throughout the season if the tender plants are not extremely succulent. If the hardening is not severe enough to induce permanent metabolic changes the reduced size may be overcome by starting the plants earlier, but this means more care and greater expense for glass space. Furthermore, the experience of gardeners and some un-

published work done by Dr. Rosa indicates that the line between hardening and stunting is sharp and a small excess of the hardening treatment may be disastrous, particularly with such plants as eggplant, cauliflower, pepper, etc., which are rather easily stunted.

SUMMARY

1. Growing plants in potometers may show over short periods reductions in transpiration from previous hardening treatments of 10 to 50 or more per cent.

2. Contrary to expectations, hardened plants are likely to transpire more than tender when both are transplanted. This is particularly true after the first three or four days.

3. Hardened plants become established more rapidly after transplanting and grow off better. This phenomenon is apparently correlated with carbohydrate reserve and new root formation.

4. Moderate hardening preceding transplanting is probably beneficial, but since the formation of a carbohydrate reserve is apparently the most important factor involved, it would seem that a fraction of the exposure normally given should be sufficient.

The Use of Statistical Data in Tomato Breeding

By H. D. BROWN and I. C. HOFFMAN, *Purdue University, Lafayette, Ind.*

THE Purdue Agricultural Experiment Station has been co-operating with the Indiana Canner's Association since 1918, in producing a high yielding canning type of tomato, suitable for Indiana conditions. As a result of this project over 15,000 pounds of tomato seed have been produced and sold by the Indiana Canner's Association. This seed is secured from about 200 acres of tomatoes at Orleans, grown from seed saved from the highest yielding selections in the breeding plots at LaFayette.

In addition to the yield records of duplicate plots necessary to determine the highest yielding strains and varieties, it is also necessary to use measures of fruit characteristics in order to be able to select the most desirable fruit types. For the past two seasons approximately 50 ripe fruits from each lot have been picked and the measurements of the greatest equatorial and polar diameters recorded. In addition the fruits are graded into five classes, representing the following basin descriptions;—1. Ideal, 2. Good, 3. Fair, 4. Poor, 5. Very poor. Another similar classification is made of the fruits basing the grades upon the amount of cracking of the skin around the cavity. The records for all varieties, strains and crosses, are all taken from pickings on the same date and all the data for any particular lot are recorded on one sheet of paper similar to the one shown below.

It will be noted that all measurements are made as simple

as possible. This is essential as over 120 lots were included in the tests this year, involving in all about 24,000 measurements. Diameters are measured in c. m. instead of m. m. as practiced by Groth (2). It is felt that this has not reduced the accuracy of the results in the least.

Measurements of the diameters are made with a caliper. The fruits from each lot are grouped into the different grades for the basin and cavity descriptions and the counts recorded directly under the frequency column. This work must be done by careful workers and preferably by the same persons each year, although pictures of the different grades are always on file. These measurements have nearly all been made by the authors.

Tomato Fruit Characteristics

Equatorial diameter, c. m.

		f	d'	fd'	fd'^2	
V.						
1						
2						
3						
4						
5						

Polar diameter, c. m.

		f	d'	fd'	fd'^2	
1						
2						
3						
4						
5						

Basin

		f	d'	fd'	fd'^2	
1						
2						
3						
4						
5						

Cavity

		f	d'	fd'	fd'^2	
1						
2						
3						
4						
5						

1. Ideal; 2. Good; 3. Fair; 4. Poor; 5. Very Poor.

All ripe fruits are picked from each lot until 50 have been picked so that the descriptions represent all types found in the lot. Sometimes it is impossible to secure 50 ripe fruits, and consequently the probable errors for such lots are somewhat larger.

The mean, standard deviation, and coefficient of variability with their corresponding probable errors, are calculated for each set of measurements. By dividing the mean for the equatorial diameter by the mean for the polar diameter, a factor for fruit shape is obtained similar to the factor used by Groth (2). Groth, however, obtained the factor by dividing the polar diameter by the equatorial diameter.

Aside from the value of the standard deviation and coefficient of variability in determining the purity of the strain, for the particular factor under question, the means are used directly in determining the value of the strains. All measurements serve as a permanent record of the performance and probable heredity of selections. Frequently the data collected bring out characteristics entirely overlooked during the growing season.

Cavity. Cracking of the fruit is especially undesirable in a canning type of tomato because bacteria and fungi breed in the cracked areas and make it very difficult for the canner to keep his mould and bacteria counts under the legal limit. The cavity classification affords an excellent measure of the ability of each lot to resist cracking and the data are used directly in deciding which lots shall be included in the following year's tests, those having the lowest mean of course being preferred. These data are, however, the most uncertain of all the statistical measurements as the parents do not seem to transmit this character to their selections to any marked degree. This is very likely due to seasonable conditions as cracking is known to be due to variations in the moisture supply. This is, of course, only one method of eliminating strains which crack, as other records are secured to determine the extent of cracking following rains etc.

Basin. The basin classification is an excellent measure of the ordinary grades of tomatoes, i. e., nearly all tomatoes classed in the first commercial grade would be included in 1 and 2 of the classification, while nearly all poorly shaped tomatoes, cat faces, etc., would be placed in class 5. This classification is of great value in selecting a good type of fruit.

Diameters. By taking measurements several times during the same season it was found that the diameters, i. e. size of fruits, varied with the season, but that the shape $\left\{\frac{\text{equatorial diameter}}{\text{polar diameter}}\right\}$ varied somewhat less. This is not in exact accord with the findings of Groth (2) who finds that "As long as the large fruits are not teratological there is little danger that they owe their greater size to environmental influence."

The diameter measurements have a direct value in determining size of fruit and purity of strain. Their greatest value, however, is in the determination of the factor for fruit shape.

Blossom-end Rot. In 1919 the trials were located on sandy soil and during a severe drought many fruits became infected with blossom-end rot. These fruits were picked, counted and weighed, and the percentage of the total crop infected by the disease was calculated. At the time the disease was most destructive the

disease free ripe fruits were also picked, counted and weighed and the average weight per fruit of each lot was calculated. It was found that a correlation of .539 ± .049 existed between the percentage of fruit lost by the point rot and the average size of fruit, indicating that the large fruits are more susceptible to blossom-end rot than small fruits. This agrees with results secured by Stuckey (4). He found the cherry parent and the F_1 of Cherry x Baltimore crosses to be immune to the disease, but the immunity disappeared as larger fruits were selected in subsequent generations.

It was also discovered in 1919, that our selections of the Red Head variety were infected less than the Baltimore, there being an average infection of 5.5 per cent for the Red Head strains and 11.7 per cent for the Baltimore strains. It was also found that a Globe variety included in the tests had the least infection of any lot, 1.6 per cent. Since the shape of the Globe is about 1.000 (not determined exactly) and that of the Red Head is 1.260 while the Baltimore fruit shape averages about 1.380 it would seem that the deep rounded fruits were less susceptible to the rot than the flattened types. Stuckey (5), however, found in one of his tests that a Globe variety produced 15.45 per cent infected fruits, while a Baltimore variety in the same test produced only 7 21 per cent infected fruits. One Globe selection from a vine bearing a high percentage of rotted fruits yielded 80 per cent infected fruits indicating that the tendency may be inherited. In view of these results and since the Globe and Red Head varieties are early, while the Baltimore is a late variety, the Purdue results are more likely due to differences in environmental conditions during the critical period of the fruit growth on the three varieties. Perhaps the fruits on the two early varieties were more mature when the conditions were favorable for the production of the rot, or it is more likely that the vines and fruits were subjected to such favorable hardening conditions as to inhibit the production of the rot. Later, Magruder (1), in working with Cherry and Baltimore crosses failed to secure any blossom end rot on either Baltimore or the crosses with the plants growing in pots in the greenhouse, although he withheld water to such an extent as to cause the vine and foliage to wilt and the fruits to shrink to almost half their normal sizes. When water was again applied the plants and fruits regained their turgidity without development of point rot. Rosa (3) suggested that hardening processes might have an effect on the point rot of tomatoes.

These plants would be classified as being low in moisture and nitrogen content, and as having a comparatively high carbohydrate and dry matter content. At any rate the results indicate that it is unsafe to compare early and late varieties started at the same time, given the same care and grown in he same field, without considering stage of maturity and condition of plant. Many varieties and types have been included in the tests since 1919 in order to secure more data on this subject, but the seasons since then have all been unfavorable for the development of blossom-end rot.

The shape of fruit data have also been used to verify an

observation which indicated that depth of fruit (polar diameter) was associated with well shaped fruits. A correlation of .4202 ± .0532 was found between the factors for shape of fruit and the basin classification. This is not a very significant correlation, but it strengthens the conclusions drawn from observations. Selections during the past two years have been made to secure a rounded rather than a flattened tomato.

Eleven selections made in 1922 from six lots whose fruit ratio was below 1.300, produced six ratios in 1923 below 1.300, in spite of the fact that the mean ratio for all selections in 1923 was 1.381 as compared to a mean ratio of 1.361 and 1.370 for the two records in 1922. Only two of the 59 selections grown in 1923, whose parents had a ratio of above 1.300, produced a ratio of below 1.300. The foregoing data give some idea of the value of these data in predicting the performance of certain selections. The ratio mentioned above seems to have the greatest value of any of the data in this respect.

Summary

1. The statistical measurements afford an excellent measure of fruit types which might otherwise go unnoticed.

2. They are an aid in the selections of lots which are homozygous for fruit type.

3. The basin and cavity data are very valuable in choosing selections which produce desirable fruits from the standpoint of shape and freedom from cracking.

4. The diameter measurements are an indication of size and shape of fruit and may possibly be used in correlation tables to determine the tendencies of certain types of fruit to become infected with blossom-end rot.

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Factors Influencing Early Development of Seed Stalk of Celery

By H. C. Thompson, *Cornell University, Ithaca, N. Y.*

CELERY started in the greenhouse or hotbed early in the season and set out as soon as the weather conditions permit, often goes to seed long before the plants reach full size. This frequently results in considerable loss to the grower, and it was this fact that

led the writer to begin a study of the problem. In vegetable gardening literature the following factors are given as those most likely to be responsible for the premature development of the seed stalk of celery:

(1). Checking growth of the plants due to freezing, drying and any other condition retarding development, but freezing in particular has been emphasized.

(2). Poor seed, especially seek lacking vitality.

(3). Starting plants early in the winter.

As already suggested the checking of growth by freezing is most often given as an explanation of early development of the seed stalk, due probably to the fact that in the North celery is often set in the field before freezing weather is over.

In order to determine the effects of some of these factors on seed-stalk development, the writer began some experiments in the winter of 1918 and has continued them for five years. Some studies have been made on all of the factors mentioned above. A good strain of Golden Self Blanching celery, tested previously for trueness to type, has been used each year. The seed was sown in flats in the greenhouse in the usual way and transplanted to stand 1½ by 1½ inches as soon as they reached sufficient size. The usual care was given the plants, except where the experiment had to do with a particular treatment. Thus far the studies have been confined to the effects of the following treatments on the development of the seed stalk:

1. Time of starting plants.
2. Checking growth by withholding water for a period before the plants were taken to the field.
3. Checking growth due to crowding the plants in the flats.
4. Subjecting plants to freezing temperatures.
5. Subjecting plants to relatively low temperatures, but not freezing, for a considerable period prior to setting them in the field.

While the experiments have been carried on for five years the tabulated results are for only four years, since in one year (1921) no seed stalks developed on any of the plants due to injury by disease in the heart. For convenience in presenting the data each factor is discussed separately.

Effect of Time of Sowing Seed on Seed-Stalk Development

In order to determine the effect of the time of sowing seed on the development of the seed stalk, four plantings have been made each year as follows: December 10, January 10, February 10 every year, March 10, 1919 and 1920, and February 25, 1921, 1922 and 1923. It was planned to have the plantings made one month apart, but, after the first two years, it was deceided to make the last planting February 25 instead of March 10, since the latter date is too late for early celery at Ithaca, New York. The crop has been grown on a good sandy loam soil, given good care and attention. The treatments were in duplicate. Examinations and counts were made several times during the growing season, the first soon after planting. The results have been summarized to give the percent-

age of the plants showing seed stalks at three periods. Table 1 shows the number and percentage of seed stalks developed in 51, 72 and 111 days.

TABLE I

Number and Per Cent of Celery Plants Showing Seed Stalks in a Given Number of Days. Average of Four Years

Date of seed sowing	Total No. plants	51 days Number	51 days Per cent	72 days Number	72 days Per cent	111 days Number	111 days Per cent
Dec. 10	469	312	65.52	411	87.63	432	92.10
Jan. 10	468	137	29.27	292	62.40	355	75.85
Feb. 10	469	5	1.00	90	19.20	169	36.00
Feb.† 25 ...	...	...	.....	...	.....	...	.....
Mar.* 10 ...	477	0	0.00	2	0.40	16	3.25

†February 25, 1922 and 1923.
*March 10, 1919 and 1920.

The data in Table I show that the earlier the seed was sown the earlier the plants went to seed and the greater the percentage of seed stalks developed. A good crop of viable seed was developed on the plants grown from seed sown December 10 and January 10, but no seed ever developed on any of the plants started later. This is a possible method of growing seed and may be found to be of importance, especially in experimental work.

EFFECT OF WITHHOLDING WATER ON DEVELOPMENT OF SEED STALK

Each year some of the plants were seriously checked in growth by withholding water for some time before setting them in the field. These plants were yellow and wilted when ready for planting. The soil of the flats was thoroughly soaked just before taking out the plants so that they could be taken up with soil adhering to the roots as in comparable lots kept normally moist. The results of this treatment are given in Table II.

TABLE II

Number and Per Cent of Celery Plants Showing Seed Stalks Under Two Different Treatments

Date of seed sowing and Treatment	Total Number Plants	51 days Number	51 days Per cent	72 days Number	72 days Per cent	111 days Number	111 days Per cent	Number of years
Dec. 10 Dry	180	56	31.11	131	72.78	150	83.33	2
Dec. 10 Moist	241	137	56.84	197	81.74	208	86.30	2
Jan. 10 Dry	459	37	8.06	136	29.63	221	48.15	3
Jan. 10 Moist	454	66	12.33	196	43.17	264	58.15	3
Feb. 10 Dry	551	1	0.18	10	1.81	93	16.88	4
Feb. 10 Moist	556	5	0.90	32	5.35	115	20.68	4
Feb. 25 Dry	200	0	0.00	0	0.00	6	3.00	3
Feb. 25 Moist	387	0	0.00	2	0.51	16	4.13	3

In Table II "Moist" refers to the plants that were kept normally moist all of the time prior to being planted in the field, while "Dry" refers to the plants that were dried out before being planted out. It will be observed that in every case more seed stalks were developed on the plants kept moist than on those checked by drying. In every instance the plants kept moist developed seed stalks earlier than those that were dried out. The greatest difference was noticed early in the season. It seems probably that checking growth while the plants are small, delays the development of the seed stalk because such plants require a longer time to develop sufficient leaf surface to manufacture enough food to maintain growth and store a surplus for seed-stalk development than do similar plants not checked in growth. After plants have attained considerable size, checking growth may have a different effect, and observations would lead me to believe that it does. For example, more seed stalks develop in a year when there is little rain after the plants get half grown, or more than in a year when there is abundant moisture throughout the growing season However, this is seldon a factor in early celery growing in humid climates.

Effects of Crowding Plants in Flats on Subsuquent Development of Seed Stalk

In all of the tests except the one under discussion all of the plants were spaced $1\frac{1}{2}$ by $1\frac{1}{2}$ inches apart in the flats which were two inches deep. Plants started in December and January became considerably crowded and checked in growth before time for setting them in the field. In order to determine if this check in growth hastened the development of the seed stalk some of the plants from seed started December 10, 1922, and January 10, 1923, were transplanted 2 by 2 inches apart in flats four inches deep. Each plant set $1\frac{1}{2}$ by $1\frac{1}{2}$ inches apart in flats 2 inches deep had the equivalent of $4\frac{1}{2}$ cubic inches of soil, while the others had the equivalent of 16 cubic inches of soil. The plants grown by the latter method were not checked in growth before being set in the field. Table 3 gives the results of this experiment.

TABLE III

Effects of Check in Growth by Crowding on Seed Stalk Development

Date of seed sowing and Treatment	Total Number Plants	Number and per cent seed stalks 45 days		63 days		110 days	
		Number	Per cent	Number	Per cent	Number	Per cent
Dec. 10 Shallow Flat	141	65	46.10	120	85.10	127	90.00
Dec. 10 Deep Flat	101	57	56.43	81	80.20	95	94.06
Jan. 10 Shallow Flat	141	0	0.00	35	24.82	63	44.68
Jan. 10 Deep Flat	105	0	0.00	34	32.38	55	52.86
Feb. 10 Shallow Flat	142	0	0.00	13	9.15	47	33.33
Feb. 10 Deep Flat	140	0	0.00	33	23.57	67	47.85

While the results given in Table III are for only one year and the differences are not great, they show that the plants which were

not crowded in the flats had a higher percentage of seed stalks at each period than those not checked in growth. The latter were later in sending up seed stalks in all of the lots.

Effect of Low Temperatures on Seed-stalk Development

In 1919 and 1920, all of the plants were subjected to temperatures considerably below freezing. In 1919, the ground froze a half inch deep the first night the plants were in the field and freezes occurred for several nights thereafter. The following year the plants were also subjected to freezing temperatures several times during the first 10 days in the field, but the plants from the last sowing of seed did not produce seed stalks. This led to the conclusion that freezing did not cause plants to go to seed. In 1922, some of the plants were purposely subjected to freezing temperatures prior to planting them in the field and these were severely injured, especially those from the later sowings. Many were killed, but those remaining were planted along with comparable lots which were not subjected to freezing. The results are shown in Table IV.

TABLE IV

Effects of Freezing Plants on Seed Stalk Development in 1922

Date of seed sowing and Treatment	Total Number Plants	Number and per cent seed stalks 58 days		94 days		105 days	
		Number	Per cent	Number	Per cent	Number	Per cent
Dec. 10 Not Fr.*	141	99	70.0	133	94.0	137	98.0
Dec. 10 Froze	50	8	16.0	40	80.0	41	82.0
Jan. 10 Not Fr.*	137	47	34.0	120	86.0	121	86.5
Jan. 10 Froze	69	2	3.0	40	58.0	40	58.0
Feb. 10 Not Fr.*	137	5	3.6	32	23.0	33	23.5
Feb. 10 Froze	31	0	0.0	3	9.5	4	13.0

*Not Fr. –Plants were not subjected to freezing.

The number of plants used in this test is too small to justify definite conclusions, but the results are interesting in that they show delayed development of the seed stalk due to freezing.

While freezing apparently delays development of the seed stalk, there is some evidence that subjecting plants to relatively low temperatures, but above freezing, for a considerable period, has the opposite effect. Whipple has reported results in which the plants subjected to relatively low temperatures for 40 days prior to setting them in the field, produced more seed stalks in a given length of time than comparable lots of plants kept at higher temperatures. During the past year the writer secured similar results. Some of the plants from seed sown December 10 and January 10, were placed in a cold frame April 10 and kept there until April 27, when they were set in the field. During this time the temperature in the cold frame never went below 35 degrees F., but was around 40 degrees most of the nights. Comparable lots were kept in the greenhouse during this period and these were set out on April 27. Table V gives the results of this test.

TABLE V

Effects of Relatively Low Temperature for 17 Days on Development of Seed Stalk

Date of seed sowing and Treatment	Total Number Plants	Number and per cent seed stalks					
		45 days		68 days		103 days	
		Number	Per cent	Number	Per cent	Number	Per cent
Dec. 10 Low T.* ..	105	68	64.66	101	96.20	103	98.10
Dec. 10 Greenh.† ..	141	65	46.10	120	85.10	127	90.00
Jan. 10 Low T.* ..	105	0	0.00	84	80.00	92	87.60
Jan. 10 Greenh.† ..	141	0	0.00	35	24.82	63	44.68

*Low T.—Plants subjected to relatively low temperature for 17 days.
†Greenh.—Plants kept in greenhouse during same period.

It will be observed that the exposure of these plants to relatively low temperatures, had a marked effect on seed-stalk development. It is much less marked in the plants from seed sown December 10 than from January sowing. The plants subjected to the conditions in the cold frame were not noticeably checked in growth. When planted in the field those from the cold frame and those from the greenhouse grew well and there was no observable difference between them until seed stalks began to develop. What effect this low temperature would have on younger plants remains to be determined. The writer does not attempt, at this time, to explain what happens in the plant that causes stimulation resulting in hastening the development of the seed stalk.

DISCUSSION

From the results reported it seems to the writer that we must look to factors other than checking growth of the plants while small for an explanation of early development of the seed stalk of celery. In fact, checking growth at this stage materially delays seed stalk development. Plants started in December and January produce seed stalks in May, June and July regardless of the treatment they are subjected to early in their life, while plants started considerably later do not produce seed stalks normally and are not stimulated to do so by any of the treatments tested. The length of day may be a factor to be considered since celery plants started in the spring do not produce seed stalks although they are full grown before fall. The writer has taken up full-grown plants and set them in the greenhouse in the fall, but has had no seed stalks develop until the following spring. This indicates that size and age of the plant, and good conditions for vegetative growth are not sufficient for the development of the seed stalk. It seems entirely possible that the daylight period during winter is too short for manufacture of sufficient carbohydrates to provide for both vegetative growth and reproduction. This factor is being studied at the present time by using artificial light to lengthen the period of light.

Influence of the Time of Maturity of Onions Upon the Rest Period, Dormancy, and Responses to Various Stimuli Designed to Break the Rest Period *

By V. R. BOSWELL, *University of Maryland, College Park, Md.*

INTRODUCTION

IN the storage of onions there are frequently rather heavy losses due to the bulbs starting growth before the end of the storage period. The investigations reported in this paper were carried out in an effort to determine some of the factors which control the length of the rest period, and to devise if possible a means of managing the crop, other than cold storage, which would result in an increased tendency to remain dormant, with a consequent suppression of growth during storage. The work herein reported was a continuation and an outgrowth of investigations started at the Maryland Station in 1920, by Dr. Henry A. Jones, now of the University of California.

EARLY VERSUS LATE MATURING ONIONS

In order to determine whether the time of maturity of the bulbs exerted an influence on the length of the rest period and the tendency to remain dormant during storage, they were harvested at two different times. At College Park, Maryland, by the latter part of July, 1922, 18 weeks after planting the seed, many bulbs had reached such a stage of maturity that the necks weakened and the tops fell to the ground. The greater portion of the crop, however, was still growing. Several bushels of these early maturing individuals were harvested the last week in July, and cured for three or four days in the sun in the field. This lot of onions shall be referred to throughout this discussion as "early maturing." The remainder of the crop was harvested four weeks later. soon after the tops and roots had become dead and dry. These also were cured in the sun in the field for three to four days. This second portion of the crop shall be known as "late maturing" bulbs.

Those which matured early ran slightly larger in size than the average for the remainder of the crop, and are slightly different in certain other respects. They differ in their chemical composition (Table I) and in their affinity for water (Table II).

*In this paper the term "rest period" refers to that state of the bulb in which no growth can be induced by placing it under conditions most favorable for growth. The terms "dormancy" and "dormant period" refer to that state of the bulb in which no growth is evident, but in which growth may readily be induced by supplying conditions favorable for growth.

TABLE I

*Chemical Composition of Early and Late Maturing Onions**

	Early Maturing	Late Maturing
Moisture (fresh weight)	89.5	89.1
Dry matter (fresh weight)	10.5	10.9
Free reducing substances	26.6	25.6
Sucrose	29.6	27.3
Total sugars	56.2	52.9
Hydrolyzable polysaccharides	6.9	6.9
Total carbohydrates	63.1	59.8

*Expressed in terms of percent dry weight.

The above analyses are based upon composite samples composed of twice the theoretical number of individals required to give a probable error which is sufficiently low to allow one to consider a relative difference of 5 per cent as significant. The differences in the content of the various constituents are small; yet the internal balance of carbohydrate materials which are active in metabolism, differs in the early and late maturing individuals and suggests that there is a chemical basis for the differences in behavior which are recorded in the data which are to follow.

TABLE II

Moisture Loss in Per Cent of Original Total Water

	Early Maturing	Late Maturing	Greater Loss from Late Maturing
Moisture content	89.5	89.1	
Loss after 29 days	1.24	1.79	44
Loss after 59 days	2.68	3.69	38

In the determination of moisture loss from the onions, 40 bulbs of each lot were placed in separate desiccators, each of which contained a large beaker of concentrated sulphuric acid. The comparative rates of moisture loss from the bulbs was determined by noting the increase in weight of the vessel of sulphuric acid. The fact that the late maturing bulbs lost a much greater proportion of their total water than did the early bulbs, suggests that there is a difference in permeability to water.

THE LENGTH OF THE REST PERIOD

Studies on the rest period were for the most part similar to those conducted at this station by Dr. Jones, a preliminary report of which was read before this society in 1920*. The seasonal conditions under which the bulbs have been grown in the following years have varied of course, so differences in the time of harvesting of the bulbs and carrying out the various experiments are to

*Jones, H. A. Onion Dormancy. Proc. Amer. Soc. Hort. Sci., 1920.

be expected. Nevertheless, the later experiments confirm the earlier work.

A large percentage of the early maturing bulbs which were harvested the last part of July and a few days later placed in a warm moist soil, showed a starting of top growth about the first of October. These results were fairly consistent in three years' work as shown in Table III.

TABLE III

Starting of Growth

Year	Time After Harvest	Per cent of Bulbs Showing Growth
1920	10 weeks	35
1921	11 weeks	30
1922	10 weeks	50

At weekly intervals, similar lots of bulbs which had been treated the same as those just mentioned, were dissected for the purpose of determining when scale elongation began. The first scale elongations could be detected between one and two weeks before they appeared through the apex of the bulb. As soon as the late maturing bulbs were harvested they were planted, and studied in the same manner as noted for the early maturing individuals. Although the late maturing bulbs were planted four weeks later than the others, scale elongation began but about a week later. It is difficult to say definitely at what time the rest period ends and growth begins, for there is so much variation in this character, among apparently similar individuals. In the Yellow Globe Danver onion the rest period is evidently ended in about eight weeks, with but a few days if any difference between the early and late maturing bulbs. Apparently similar bulbs may vary several days in the time that they started growth.

Last fall one lot each of the two kinds of bulbs was held at room temperature for a month before they could be planted, then were placed in a warm, moist soil in the green-house. Four weeks later 25 per cent of the early maturing bulbs had produced leaves, while 40 per cent of the late maturing bulbs had done so. The leaves of the latter group were noticeably longer at that particular time, but as the tops attained their full size these differences disappeared. Since there is so much variability in the material used, it is hardly possible to say just to what extent the time of maturity affects the length of the rest period, but there seems to be a slight effect, which will be brought out by further data.

Mode of Scale Elongation

It is commonly known that within the several scales which are subtended by leaves the first year of growth, there is a group of concentric, leafless scales. They are roughly conical in shape, and the outermost is terminated by a point which lies just beneath the apex of the bulb. The outermost of these leafless scales lies adjacent to the innermost leaf-bearing scale. Until the starting

of growth each scale is completely enveloped by the scale which surrounds it, except in rare cases in which the tip of one scale may protrude through the tip of the scale surrounding it.

When the rest period is ended it is this group of undeveloped leaf scales which elongate to produce the new crop of leaves. The number of these leafless scales varies, but it is usually eight to 10. The innermost scale is the smallest, usually having a length of about one millimeter. Counting from the outside, the first three scales show practically no growth at any time. When growth starts the fourth elongates slightly and the fifth pushes through a small opening near the tip of the fourth, slightly surpassing it in length. Each succeeding scale then pushes through the opening in its immediately surrounding scale and surpasses it in length. The seventh and sixth scales, respectively, make the most rapid early growth; and before any of the elongating scales have appeared above the top of the bulb, they have pushed through the openings near the tips of their surrounding scales and are ready to emerge. The mode of scale elongation in the early stages of leaf extension may be likened to the extension of a many-sectioned collapsible telescope.

Breaking the Rest Period

These experiments were started the first of August, certainly before the rest period was ended. Four different treatments were applied in attempts to break the rest period.

1. *Wounding.* By transverse cuts through the bulb, the upper one-third, one-half and two-thirds, respectively, were removed from each of three lots of 40 bulbs. The basal portions were then planted in a warm, moist soil. Nine days later they were examined, and those bulbs which had been cut in half showed about a half centimeter of growth of the inner scales. Those from which the upper third had been removed showed practically no growth, while those from which two-thirds had been removed showed decidely more growth than the first. The difference was even more striking a few days later when those which had been the most severely treated had made by far the most growth, and the bulbs from which one third had been removed were just well started. No growth was evident in the untreated bulbs which were planted as a check. Three years' work indicates rather strongly that the closer the cut is made to the growing point, the greater is the growth response. Of course it is possible to cut so close to the growing region as to cause injury, or to remove so great a proportion of the storage tissues that insufficient storage materials are available for growth.

Longitudinal cuts were made upon other lots of bulbs in such a manner that only a four-sided central portion remained. Care was taken not to cut through the stem plate, injure the growing region, or to remove the apical portion of any of the scales Growth occurred much sooner in the bulbs so treated than in the check, but about a week later than in the bulbs which were cut in half transversely. Longitudinal gashes through the stem plate greatly stimulated root growth, but no top growth occurred. The

failure of these bulbs to produce leaves may have been due to injury of the growing region when the cuts were made, for when the longitudinal cuts were made near the growing region without passing through the stem plate, top growth was stimulated. The fact that different ways of cutting and wounding the bulbs did not produce similar growth responses, indicates that the responses were due to some stimulus other than that of wounding. A free passage of the gases active in metabolism was believed to be responsible in part for the prompt growth response in the bulbs which were wounded by transverse cuts. The closer the cut was made to the growing region the more marked was the response except in the case of the longitudinal cuts when compared with the transverse cuts. When the cuts are made longitudinally it is necessary for the gases to diffuse *through* the mass of remaining scales to the growing region, rather than down *between* the scales as is possible in bulbs which have been cut transversely. An observation which strengthened this belief, was that bulbs known as "thick-necks" having a loose and somewhat separated arrangement of the scales, would invariably start growth sooner than any other of the unwounded bulbs. The probability of this matter of gas exchange being a factor in the observed stimulation of growth, will be dealt with later in this report.

No appreciable differences in response to wounding were noted between the early and late maturing bulbs.

2. *Etherizing.* When ether was used in an effort to break the rest period, quite variable results were obtained. Two seasons' work shows that the exposure of the bulbs to an atmosphere saturated with ether at room temperature before planting, resulted in no consistent increase or decrease in the percentage of growing bulbs over that found in the check, four weeks after planting. This is illustrated in Table IV.

TABLE IV

Growth Response of Onion Bulbs to Etherization

Time of Maturity	Exposure to Ether	Per cent of Growing Bulbs after 4 Weeks
Early	15 minutes	5
Late	15 minutes	25
Early	30 minutes	10
Late	30 minutes	27
Early	45 minutes	5
Late	45 minutes	25
Early	1 hour	12
Late	1 hour	22
Early	2 hours	7
Late	2 hours	10
Early	Check	12
Late	Check	20

Time of Maturity	Exposure to Ether	Average Top Length After 2 Months
Early	1 hour	19.3 cm.
Early	2 hours	22.2 cm.
Early	6 hours	14.2 cm.
Early	12 hours	12.1 cm.*
Early	24 hours	all rotted
Early	Check	25.6 cm.

*40 per cent decayed.

Treatment for 12 and for 24 hours caused the bulbs to rot badly, the latter exposure resulting in a total loss of the bulbs which were treated. Treatment for such a short period of time as 15 minutes appeared to retard the growth of the early maturing bulbs, but the late maturing bulbs were not markedly affected. The outstanding fact revealed in the above table is that the early maturing bulbs grew much less readily than the late maturing bulbs. As a whole, the effect of ether upon the stimulation of growth was so variable that no definite response can be ascribed to the treatment, except in the cases in which injury and decay were produced.

3. *Freezing.* Through the courtesy of the Office of Horticultural Investigations of the United States Department of Agriculture, the controlled temperature rooms of the cold storage laboratories at Arlington Farm, Virginia, were available for this work. Studies were made of the influence of low temperature upon the rest period.

Lots of 40 bulbs each of early and late maturing onions were placed at a temperature of 22° F. (-5.5° C.) for periods of 2, 4, 6, 24, 48 and 72 hours respectively, then planted in warm moist soil within two to three hours after removal from the cold room. These tests were made immediately after the harvest of the late maturing bulbs before the rest period was over. After the bulbs had been exposed to the low temperature for four hours or longer, they were inoculated by tapping sharply with a pencil to insure that freezing would occur.

TABLE V

*Response to Exposure to Low Temperature**

Early Maturing			Late Maturing		
Hours Exposure	Per cent Dead	Per cent Dormant	Hours Exposure	Per cent Dead	Per cent Dormant
2	0	55	2	15	60
4	5	32	4	25	60
6	10	55	6	0	70
24	15	40	Check	20	25
48	10	72	.	..	..
72	30	50	.	..	..

*Observations made nine weeks after planting.

It will be observed that certain of the treatments resulted in the death and decay of some of the bulbs before growth occurred. This loss may have been due to the killing of the tissue by low temperature, but if this was the case, the percentage of killing seemed to be determined by some factor other than the length of exposure to the low temperature. There is no significant correlation between the length of exposure to low temperature and the percentage of bulbs which failed to grow, or between the length of exposure and the percentage of bulbs which decayed.

It is known that many herbaceous perennials may be forced into early growth by freezing for a day or two. Howard, working at the Missouri Station, subjected 65 species of herbaceous perennials to various etherizing and freezing treatments to break the rest period. Various species responded differently to the treatments, but in the summary of his results he states, "Freezing was perhaps the best treatment for forcing early growth."* Bulbous plants, however, behave in a different manner, for in the same report Howard states, "Preliminary treatments with ether and other agents which have been successfully used in breaking the rest period of woody plants, failed to arouse bulbs into growth, especially during the earlier part of their dormant period."* The results of studies upon the rest period of the onion at the Maryland Station indicate that it is typical of other bulbous plants with respect to its response to stimuli designed to break the rest period.

It may be that a shortening of the rest period will result if the bulbs are merely chilled at a temperature of 31° to 32° F. for a number of days. The data indicate that freezing is decidedly harmful.

4. *Greening.* Twenty bulbs were set upon warm moist soil with only the basal portions covered. The greater portion of the surface of the bulb was left exposed to the sun to determine if greening and early sprouting would occur as in the potato. After two months these bulbs had developed a barely perceptible amount of green color and had made but 62 per cent as much growth as the check bulbs which were submerged in the soil just beside them.

Gas Exchange and Growth

The behavior of the bulbs from which varying portions had been removed by transverse and longitudinal cuts, suggested that one of the chief factors inducing growth was a ready exchange of gases. Oxygen was believed to be the activating material. To prove that growth was not induced by a wound stimulus, and to test the validity of the gas exchange idea, 40 bulbs were cut in half transversely and the freshly cut surface of 20 of these was covered with a low melting-point paraffin to exclude the air. The other 20 were retained as a check, and all were planted. Five days later the checks showed a growth of two to three millimeters, while no growth was evident in the bulbs which had been paraffined. A month later there was still no growth evident in those paraffined bulbs in which the seal was intact. In cases in which the paraffin

*Howard, W. L. The Summer Rest of Bulbs and Herbaceous Perennials. Mo. Agr. Exp. Sta. Res. Bul. 15 p. 25. (1915)

had cracked or loosened at the edges and permitted an exchange of gases, there was a growth of the inner scales of from two to three millimeters to more than a centimeter. The leaf growth of the checks was 15 to 20 centimeters at this time.

The above observations suggested that the exclusion of oxygen, the retention of carbon dioxide or some other gas, or a combination of both factors, prevented growth in bulbs during the rest period; and that an increased permeability of the cells which will permit a ready exchange of gases, is one of the changes which occurs that is responsible for the termination of the rest period.

To further follow up the matter of availability of oxygen, and to eliminate the possibility of a retention of growth inhibiting gases within the tissues of the bulbs, an experiment was designed which yielded quite suggestive results. The exclusion of oxygen was effected in such a manner as to permit an easy escape of any gaseous products from the tissues. A number of transversely bisected bulbs were placed in a large desiccator containing a broad, shallow vessel of concentrated sodium hydroxide solution, for the purpose of absorbing excessive quantities of carbon dioxide. A current of air was drawn through the desiccator, from which the oxygen had been removed by bubbling it through a concentrated solution of pyrogallic acid. The air was first drawn slowly through the desiccator for about two hours to displace all the oxygen originally enclosed; the vessel was then closed air tight. A check was run with a lot of similar bulbs in a similar container with a vessel of concentrated sodium hydroxide. In this latter case the vessel was loosely covered, giving free access to atmospheric oxygen. After eight days most of the bulbs in the check had made a growth of one to two centimeters, while those confined in the oxygen-free atmosphere had made a barely perceptible elongation of the scales. To determine whether this inhibition of growth in an oxygen-free atmosphere was due to the lack of necessary gaseous materials, or whether some injury to the bulbs had resulted, both lots of bulbs were planted in a warm moist soil after removal from the desiccators. All bulbs proceeded to grow normally, and after a few days no difference in growth between the two lots could be detected. The above observations suggest that the availability of oxygen to the growing region, rather than the retention of other substances is one of the factors which determine when growth shall start in bulbs that are under conditions favorable for growth to occur. These experiments upon the exchange of gases cannot be considered conclusive, but they are of interest since they suggest one of the factors influencing the rest period of the onion.

Does the Time of Harvesting Influence Behavior

When these investigations were begun it was believed that by harvesting at different times, and handling the onions in different ways, it might be possible to so alter the internal balance of materials active in metabolism that the rest period would be lengthened and changes would be effected in the subsequent vegetative and reproductive development. But in view of the inherent variability discovered in the Yellow Globe Danver onion, it is

entirely possible that what may have been done in harvesting the early maturing individuals as described, and leaving the remainder of the crop in the field until all were well matured, was an unconscious selection of a distinctly different type of bulb—one which had always been different from those which mature late, and which would behave in the manner observed regardless of the time of harvesting and method of handling. The following paper* in this report of the Society shows that dormancy is more pronounced in early maturing bulbs than in late maturing bulbs.

Summary

1. Early maturing Yellow Globe Danver onions differ from late maturing onions in their chemical composition and moisture holding capacity.

2. The length of the rest period is not greatly different in the two kinds of bulbs, but those maturing early start growth somewhat less readily than the others.

3. Morphological studies incidental to the studies on the length of the rest period revealed the mode of scale elongation in the early stages of leaf extension.

4. Removal of portions of the bulbs by transverse or longitudinal cuts results in a stimulation of growth of leaves.

5. The removal of portions of the bulbs by longitudinal cuts did not produce as prompt a response as equally severe transverse cuts.

6. The closer the cut was made to the growing region, the more promptly was the starting of growth, granting that no injury to the growing region of the scales occurred.

7. The stimulus to growth brought about by removal of portions of the bulb seems to be associated with an increased availability of oxygen rather than with a wound stimulus.

8. The rest period could not be broken by etherizing or freezing. In general, the treated bulbs produced less growth than the checks.

9. Exposure of the bulbs to sunlight for the purpose of "greening" evidently retarded rather than stimulated growth.

10. Any difference in the behavior of early and late maturing onions may be due to an inherent variation in the bulbs rather than to any change in the nutritional balance effected by harvesting at different times and handling by different methods.

* The Influence of the Time of Maturity of Onions on the Behavior During Storage, and the Effect of Storage Temperature on Subsequent Vegetative and Reproductive Development. Boswell, V. R.

Influence of the Time of Maturity of Onions on the Behavior During Storage, and the Effect of Storage Temperature on Subsequent Vegetative and Reproductive Development.

By V. R. BOSWELL, *University of Maryland, College Park, Md.*

INTRODUCTION

A DIFFICULTY which onion growers sometimes experience, is the shooting to seed of set onions which have been planted for the production of green, or bunching onions. This trouble and that of growth during storage, which was referred to in the previous paper in this report of the Society, may at first seem to be entirely unrelated, but it will be seen presently that both are closely linked with the matter of storage temperature.

The storage experiments were performed in an effort to reduce to a minimum the losses from growth and decay during the storage period, and to study the influence of storage conditions on the subsequent growth of the onions. The study of floral development was planned as a separate problem; but in the course of the work it was found that the storage temperature exerts such a very marked influence upon floral development, that the observations upon that phase of the work are reported here.

BEHAVIOR OF BULBS IN STORAGE

Four one-bushel crates each, of "early maturing" and "late maturing" onions* were placed in constant temperature cold storage rooms** at 32°, 40° and 50°F. respectively. The early maturing bulbs were stored August 11, and the late maturing bulbs on August 29, 1922. On February 28, 1923, two crates of each lot were removed from the 32° and 40° rooms and placed in the 50° room to determine the effect of a marked rise in the storage temperature. On the last mentioned date only an occasional sprouted bulb could be found in either the early or the late maturing onions stored at 32°; a noticeably larger number were sprouted at 40° than at 32°, but not enough to entail an appreciable commercial loss; while those which were stored at 50° were sprouted so badly as to cause

*"Early maturing" onions are those which are the first to attain such a stage of maturity that the necks weaken and the tops fall to the ground. They were harvested as soon as this stage was reached, cured in the field two to three days then placed in storage early in August. "Late maturing" bulbs are those which do not attain the above mentioned stage until three or four weeks later. They were harvested and stored in the same manner as those which matured early.

**The writer is pleased to acknowledge the courtesy and interest shown by the Office of Horticultural Investigations of the United States Department of Agriculture, in making its facilities available for this work.

a large percentage of them to be worthless commercially. Long shoots protruded through the crates in the 50° room. One could readily see in this last case, that a larger percentage of the late maturing bulbs were growing, than of the early maturing bulbs.

On April 7, 1923, an examination of every onion in storage was made; and the percentage of those which were sound, growing, or decayed, was noted in each lot at the various storage temperatures. The following table shows some very interesting differences between early and late maturing lots which were held under identical conditions, and between similar lots of bulbs under different storage conditions. The behavior of the various lots when removed from a lower temperature to 50°F. is of interest, since it suggests the response that will result upon the removal of onions from cold storage to market conditions.

TABLE I

*Condition of Stored Onions on April 7.**

Treatment	Medium to Long Shoots	Growth Just Starting	No Growth	No Growth Decayed
Early Maturing .... 32° F. Aug. 11 to Feb. 28; 50° F. Feb. 28 to Apr. 7	10.2	8.8	76.4	4.5
Late Maturing .... 32° F. Aug. 29 to Feb. 28; 50° F. Feb. 28 to Apr. 7	28.2	12.8	48.7	10.2
Early Maturing .... 40° F. Aug. 11 to Feb. 28; 50° F. Feb. 28 to Apr. 7	7.5	4.3	83.7	4.3
Late Maturing .... 40° F. Aug. 29 to Feb. 28; 50° F. Feb. 28 to Apr. 7	18.2	8.4	65.1	8.1
Early Maturing .... 50° F. Aug. 11 to Apr. 7	19.1	9.0	68.2	3.5
Late Maturing .... 50° F. Aug. 29 to Apr. 7	20.6	6.6	69.3	3.4
Early Maturing .... 40° F. Aug. 11 to Apr. 7	4.2	5.1	89.4	1.4
Late Maturing .... 40° F. Aug. 29 to Apr. 7	20.4	10.8	58.0	10.8
Early Maturing .... 32° F. Aug. 11 to Apr. 7	0.0	0.5	98.2	1.3
Late Maturing .... 32° F. Aug. 29 to Apr. 7	0.0	1.7	89.1	9.1

*Figures expressed in terms of per cent, based on an examination of 500 to 800 onions in each lot.

It will be noticed that in the case of the onions stored at 50°F. for the entire storage period, there were greater losses from growth and decay than in the lots stored at 40° or 32°. But this loss was slightly less than in those lots which had been stored for a period of about six months at a temperature of 32° and then moved to 50° for a period of six weeks. A preliminary storage period at 32°F., which only chills the bulbs and does not freeze them, seems to be a stimulus to growth if they are subsequently placed under

more favorable growth conditions. An attempt was made to obtain a similar growth response by holding the bulbs for a much shorter period of time at a temperature of 22°F., but as noted in another paper*, the opposite resulted. The least loss occurred in the onions stored at 32°, while the losses from the lots stored at 40° were intermediate between those of the lots stored at 50° and 32°. Changing the bulbs from 40° to 50° on February 28th seems to have had no marked influence upon growth during the remainder of the storage period. From these data it seems that the most desirable temperature for storing onions is 32° to 34°F. There is, however, one difficulty with storing at such a temperature, which will be brought out by further data.

A comparison of the early maturing onions with the late maturing onions in each of the five storage treatments listed in the table, shows that in four of the five cases the early maturing lots have lost considerably less from growth than have those maturing late. On February 28, the difference between the two lots stored at 50° was so great as to be easily seen; but as time went on, the early maturing lot began to grow rapidly under the influence of the high storage temperature, and in six weeks its condition paralleled that of the late maturing lot. In the majority of cases, however, the difference between early and late maturing bulbs is appreciable. By assuming that none of those which decayed would have sprouted, even if they had remained intact, the percentage of the late maturing bulbs which show no growth is materially increased. But still there are marked differences in three of the five cases, which indicate that the early maturing bulbs remain dormant somewhat longer.

There are striking differences in the percentages of early and late maturing bulbs which have decayed, under the various storage conditions. In four of the five different treatments, the early maturing bulbs seem to be more resistant to the entrance and action of the decay organism than are those which mature late. This apparent difference in resistance to disease may be merely a difference in infection which resulted from the harvesting of the late maturing bulbs under conditions more favorable to the dissemination of the micro-organism.

Behavior in the Field After Storage

A suggestion as to the influence of the storage temperature upon the subsequent development of the onion, is found in the response of the onions which were removed from the 32° storage room after six months and placed in the 50° room for the remaining six weeks of the storage period. The chilling of the bulbs in the earlier period of storage evidently brought above changes which were especially conducive to growth. For when they were changed to a temperature of 50°F., at which conditions were more favorable for growth, a much greater response was noted than in the case in which the bulbs had been subjected to a temperature of 50°F. for

*The Influence of Time of Maturity of Onions upon the Rest Period, Dormancy, and Responses to Various Stimuli Designed to Break the Rest Period. Boswell, Victor R. Proc. Am. Soc. Hort. Sci. 1923.

the entire storage period. A storage temperature of 40° followed by removal to 50° resulted in no very marked growth response. There was, however, an increase in the percentage of growing bulbs over the lots which were maintained at 40° until the end of the storage period; but no more growth was made than by the lots which had been in the 50° room for the entire period.

It was believed that bulbs stored at 32° would show a growth response when planted in the field, similar to that observed in the case of the bulbs changed from the 32° to the 50° room. In order to determine if such a response would occur, all sound bulbs showing no growth were planted in the field on April 20, in the manner commonly employed in growing onions for seed. Both vegetative and reproductive development were studied in the plants which grew from the bulbs. Some unpublished data collected by the writer under the direction of Dr. Jones at this station* in 1922, shows that there is a correlation between the size of the bulb which is planted, and the presence, or absence, of a flower stalk. Comparatively few bulbs less than five grams in weight produced flower stalks. Eight per cent of the bulbs less than one gram in weight produced flower stalks, while 85 per cent of those bulbs between 15 and 20 grams in weight, did so. If the approximate average weights of the bulbs of a certain size are known, we know a little of what to expect in the matter of flower stalk production, other things being the same. In view of the above relation between size of bulb and presence or absence of a seed stalk, all bulbs which were planted in this work had been previously graded into four sizes: (1) less than five grams in weight, (2) five to 10 grams, (3) 10 to 20 grams, and (4) more than 20 grams.

Between June 5 and June 10 measurements were made of the length of leaves and flower stalks, number of bulbils and number of leaves per plant. The data recorded in Table II represent the two extremes and one intermediate temperature treatment. The growth made by the early and the late maturing bulbs was so near the same when the measurements were taken, that the data for both are recorded here in the case of but one temperature treatment.

The suppression of flower stalk development and the attendant increase in vegetative vigor of the bulbs stored for eight months at 32°, is quite evident when compared with similar lots of bulbs which were held at a temperature of 50°F. This plot stood out conspicuously in the field because of its greater leaf growth and the scarcity of flower stalks. The storage temperature had no effect upon the number of leaves which developed, as that number was evidently determined by the time growth ceased in the summer of the previous season. In the studies of scale length during the dormant period and growth, no increase in the number of scales was observed. There was no consistent difference in the field, in the later behavior of plants from early and late maturing bulbs, but when growth first started in the spring, the late maturing bulbs

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TABLE II

Influence of Storage Temperature on Subsequent Leaf and Flower Development

	Average weight	Per cent flower stalks	Flower stalk length	Longest leaf	Number of leaves	Number of bulbils
	Early					
32° F. for 8 months ..	3.8	0.0	0.0	9.2	3.5	1.0
	7.7	0.9	13.0	13.6	7.9	1.2
	15.3	12.3	12.1	13.7	9.9	1.7
	34.3	25.0	13.3	14.7	11.9	2.2
	Early					
50° F. 8 months	4.2	12.5	8.5	9.9	5.6	1.0
	7.7	30.2	9.2	10.2	8.0	1.3
	14.9	68.3	12.6	11.4	9.5	1.7
	27.5	81.0	12.8	11.3	11.3	2.1
	Late					
50° F. 7 months	4.1	10.0	9.5	10.7	6.7	1.2
	8.2	33.0	12.0	10.7	8.1	1.4
	14.8	69.0	12.7	11.3	10.4	1.8
	27.7	79.0	14.9	11.7	12.4	2.1
	Early					
32° F. 6½ months and 50° F. 7 weeks	6.7	9.6	10.4	10.7	6.5	1.2
	13.2	38.3	11.3	11.3	8.1	1.5
	32.3	65.2	13.8	11.4	10.6	2.2

were slightly in advance of the others. Those onions stored until the last of February at 32°, and then shifted to a temperature of 50°, exhibited a response in floral development which was intermediate between the 32° and the 50° lots, but showed a smaller percentage of flower stalks than the lots stored for eight months at 40°. A long exposure at 32° inhibited floral development more than a short exposure; and, for equal lengths of time, the storage at the lower temperature had the greater inhibiting effect. Floral development in bulbs stored at 40° for eight months was but slightly less than that of the lots stored at 50°. A marked vegetative response to storage temperature was noted only in those onions stored at 32°F.

A practical application is suggested by this response to low temperature. Further field work should be done to determine definitely the advisability of storing onion sets at a temperature of 32° to 34°F., when they are to be used in the production of green or bunching onions the following spring. The indications are that losses due to shooting to seed could be decreased greatly by storing at such a temperature. The very response that makes this storage temperature desirable from the standpoint of the market gardener, makes it equally undesirable from the standpoint of the seed grower. The seed producer desires a maximum development of floral parts, and this is evidently inhibited by storage at a low temperature. Bulbs which are to be planted for seed production, should be stored at a temperature which will reduce to a minimum

the losses from growth and decay during storage and still have no injurious effect upon floral development. This happy medium perhaps lies somewhere between 40° and 45°F.

The nature of the effect produced by low temperature upon subsequent development, is not definitely known, but certain possibilities are suggested. Whether it is an internal nutritional condition which prevents reproductive development, or whether the low temperature produces an injury and subsequent abortion of primordial reproductive tissues, has not been determined. Microscopic sections of the flower primordia in April showed the initial stage of differentiation in a few bulbs. There was a much smaller percentage of bulbs in the 32° lots which exhibited flower primordia, than in the 40° and 50° lots. Furthermore, at a given time, the stage of development of the primordia in onions stored at 40° and 50° was much more advanced than in onions stored at 32°. In these last bulbs the development had in no case examined, progressed farther than the first recognizable differentiation. No injury to the tissues as a result of exposure to low temperature was evident.

The small differences in growth and the disappearance of differences in the field are probably due to the fact that under the proper growing conditions, as the plants approach maturity and make less leaf extension, the bulbs which were slower in starting caught up with the others. The 32° lot was still considerably ahead of all other lots however, after seven weeks growth. The greater leaf development in this lot is to be expected in view of the fact that reproductive development was suppressed to such a great extent.

Summary

1. Early maturing individuals started growth in storage less readily than late maturing individuals.

2. The losses from decay were less in the early maturing onions than in the late maturing onions.

3. Storage at a temperature near the freezing point, but which does not freeze the bulbs, reduced to a minimum, the losses from growth and decay during storage.

4. Storage for six months at a temperature near the freezing point followed by six weeks at 50°, caused a much more rapid growth at the latter temperature than if the bulbs had been exposed to a temperature of 50° for the entire storage period.

5. The stimulated leaf growth brought about by storage at 32° was plainly evident under field conditions.

6. Flower primordia differentiation was materially inhibited although not entirely prevented by storing the bulbs at 32° for eight months. The lower the storage temperature, the greater is its inhibitory effect upon the flower primordia.

7. An exposure to a temperature of 32° for six months inhibited floral development less than an exposure of eight months. A long exposure at a low temperature inhibits flower development more than a short exposure.

Report of the Committee on Nursery Stock Certification

By J. K. SHAW, *Chairman, Agricultural College, Amherst, Mass.*

NURSERY stock certification under the supervision of the Massachusetts Fruit Growers' Association has made progress during the past year in four ways:

1. Work has been carried on outside the state of Massachusetts.
2. The number of varieties handled has been increased to about 25.
3. One year trees have been certified.
4. The total number of trees examined is much greater.

The following figures show the progress of the work to date:

Year	Number Examined	Number Certified	Number Refused Certification
1921	2847	2580	267
1922	8875	8437	438
1923	66815	65910	905

The trees certified in 1923 comprise probably about one or two per cent of the total number of nursery apple trees grown in the United States. The total cost has been around two cents per tree where considerable numbers were handled.

The committee presents the following statements and recommendations for the consideration of the society:—

1. That the variety certification plan of the Massachusetts Fruit Growers' Association offers the means of practically elminating misnamed trees from nursery stock.
2. That there should not be, for the present at least, mandatory legislation to enforce nursery certification; it should be encouraged to develop as the demand increases.
3. That the national organization best fitted to encourage, and if necessary to support certification work, is the American Association of Nurserymen. This is not to be considered as discouraging supervision by any regional state or local organization or agency that is prepared to undertake certification work in a careful and thoroughgoing fashion.
4. That, in order to insure the confidence of fruit growers, any agency offering certification should seek the cooperation of the official board within the state whose function is control and certification. The expert service of identification and certification should, as a rule, be drawn from, or chosen on, a recommendation from the state college.
5. That, inasmuch as the certification work is a service to the nurserymen and fruit growers, the cost should be kept as low as

possible and be borne by the nurserymen for whom the work is done, who may in turn pass it on with a legitimate profit to the purchaser of the certified trees. No practical means are evident by which the profit of the nurseryman can be controlled other than the natural law of supply and demand.

Experiments in the Propagation of Fruit-Tree Stocks

By G. E. YERKES, *United States Department of Agriculture, Washington, D. C.*

THE present study of root-stocks by the United States Department of Agriculture, was begun three years ago. The project has had the benefit of much preliminary work, however, especially from the Office of Foreign Seed and Plant Introduction. The workers now engaged in the project are being assisted by the wide experience of the men in that office, and by the collections of plant material having value as stocks brought together as a result of foreign explorations. In 1920, a representative of the Department visited the principal sections of France, Holland and England, where important quantities of nursery products are grown which are shipped to the United States in large volume. Considering the importance of these European sources, over 21,000,000 apple, pear, cherry, plum and quince stocks having been imported in the fiscal year 1923, the first-hand information gained in regard to European conditions and practices, has been very useful. During this trip the European research stations where root-stock problems are being investigated, were also visited. In 1921, a survey of American nursery conditions was made.

Nurseries for testing and propagating apple, pear, cherry, plum and rose stocks, are maintained at the Bell Horticultural Field Station near Washington, and at the United States Experiment Farm, Shafter, California. Test plots are being utilized at South Haven, Michigan, in cooperation with the Michigan Experiment Station, and at Diamond Springs, Virginia, on the land of the Virginia Experiment Station. Commercial nurseries are cooperating in the testing of stocks, particularly of citrus, peach and rose stocks, in California.

The principal lines of work started are:—Comparisons of stocks for apple and pear; the testing of stocks of seedlings of malus species and American apple varieties; the selection and propagation of individuals that give indication of special merit as stocks; the testing of rose stocks; and the vegetative propagation of fruit stocks.

From the start it was realized that American nursery practice has been projected on the basis of seedling stocks for most of our orchard trees, and it may be expected to remain to a large extent on this basis. With this in mind, much of our work has been

directed to comparing seedling stocks now in common use, and to testing seedlings from orchard trees and other sources that might supply seeds having desirable qualities. As the results thus far from these phases of our work are inconclusive, we will deal here mainly with vegetative propagation.

While recognizing that great improvement may be brought about by better choice of seeds, advantages are seen which can be derived from the sorting out of outstanding individuals and propogating them by division. Competent observers[1] have called attention to the variability in growth and other characters to be found in our important fruit stocks, and in the trees worked on them. Until we can secure uniformity in our root systems, we have solved only part of the problem in securing uniformity in the bearing part of the tree. If seed types can be found which are otherwise suitable and which supply the desired similarity, so much the better. If not, we need to turn to asexual methods, though they are likely to prove a little more expensive, and work up progenies from selected individuals. Any stock must be capable of being increased fairly rapidly, or it has small value no matter how carefully it may be selected, and its merits proven from the standpoint of compatibility, vigor, stamina, pest resistance, or other desirable qualities. Therefore, attention to propagation methods seems worth while. While investigations may bring about methods of propagating stem cuttings more readily than we now realize, the difficulty of rooting most of our important stocks under ordinary conditions makes the use of either hard-wood or soft-wood cuttings seem impracticable for general use. This difficulty has caused us to give some attention to the use of root cuttings. Propagation by division of roots is not novel in connection with fruit stocks as it is mentioned in the standard texts on propagation and has been used and discussed by investigators[2]. It has been used to quite an extent in Australia to increase aphid-resistant apple stocks. It appears, however, to be a neglected form of propagation in our American practice, and since our experiments have yielded fairly rapid increases of plants, the object of this paper is to outline our methods.

Most of our work has been done with types of apple in general use as stocks, but the same methods have been applied to a number of species of Malus, Pyrus and Prunus. During the past season in California, we have secured good stands of selected citrus stocks from root cuttings and have had some success with Salwey and Peento peach.

The larger part of our propagation work is being done at the Bell nursery, where the soil is of a sandy loam type. The trees that are to be used for root cuttings are lifted and stored over winter in the usual manner, or left in the nursery row till spring. The roots are trimmed back to stubs and the parent tree planted

[1] W. J. Webber, Jour. Heredity, Vol. 11, 1920 and Proc. Am. Soc. Hort. Sci. 1922; R. G. Hatton, Royal Hort. Soc. Jour. 42, pts. 2-3, September, 1917. Gardner & Bradford, "Principles and Practices of Fruit Growing."

[2] J. K. Shaw, Bul. 190, Mass. Expt. Sta., R. G. Hatton, Jour. of Pom. August, 1921; Jour. Royal Hort. Soc. July, 1920.

back to grow one season when the process is repeated. By far the best results are being secured by beginning propagation from one year old trees. Cuttings from two-year and older roots, give poorer stands and also tend to form undesirable root systems. Cuttings from roots of mature apple trees often form leaf buds, then fail, because new roots do not develop. To secure a start from mature trees, the younger active roots are found preferable.

No advantage has been found in making up the cuttings in winter and storing them to callous. They seem to grow just as readily if left on the parent trees until planting time. This makes an important saving in handling.

The best sizes for planting in the open ground are those from three-sixteenth to one-half inch diameter and cut into lengths of two to two and one-half inches. Cuttings from near the collar give about the same stands as those of comparable size farther out on the root system. Even very small pieces from the root tips form plants, if the conditions are favorable, but these small cuttings often fail when planted in the open ground.

The adventitious leaf buds usually form at the primal end of the cutting and the roots at the distal end, no matter in what position it is planted. In Malus and Pyrus, the leaf buds come through the outer bark, while in Prunus they push through the callous material on the end. In order to bring about the best conditions for growth and to make shapely roots, the cuttings need to be planted upright with the top end just below the ground level. Planting time in the vicinity of Washington is from March 15 to April 15. Three to four inches in the rows is suitable planting distance. Under our conditions active root growth starts and the tops push through the ground in about 30 days.

To develop progeny from selected individuals more rapidly, we have resorted to dividing the roots into pieces an inch or less in length and also utilizing the very small roots. These are potted and started in March in a cool propagating house, without artificial heat. As soon as they are well started, they are shifted to the nursery. By this means, 20 to 40 plants are often secured from a single one year old tree. In one case we obtained 66 plants from a one year old seedling of a domestic apple. Using these 66 to repeat the process the next year, 636 plants were secured. Additional increases might have been obtained from these individual tree propagations by utilizing the tops for grafting onto other stocks and handling them to develop scion roots.

The size of plants from root cuttings has averaged larger at the end of the season's growth than seedlings of the corresponding species. In our work at the Bell Nursery and at Diamond Springs, apples usually attain suitable diameter for budding by August of the first season's growth. Myrobalan and other plums from root cuttings often develop quickly enough for June budding.

The larger size cuttings usually send up several shoots. When increase of material is the object, we have utilized this tendency by mound layering them. When left for the second year of mound layering overcrowding has developed in the four-inch planting distance. The roots should stand at least eight inches apart in

rows from four to five feet apart. The stems root most readily if the mounding is commenced by the time the plants are five or six inches high. Drawing up the soil needs to be repeated two or three times as the growth develops, so that the lower part of the stem is in constantly moist soil. It should be noted, however, that this method brings about conditions favorable for woolly aphis. At the Bell nursery, root cuttings from domestic apple seedlings planted in March, 1922, gave an average increase of very nearly two plants per cutting. The plants were removed that fall and the original roots left undisturbed to grow shoots to layer again in 1923. At the time of writing, December, we have not counted the shoots which have developed this season, but estimates made during the season indicate about four plants per cutting, or about double the increase of 1922.

Bud and Root Selection in the Propagation of the Apple*

By Karl Sax, *Experiment Station, Orono, Maine.*

EXPERIMENTS have been in progress at the Maine Agricultural Experiment Station for several years, to determine the effect of selecting piece roots and scions from productive and unproductive trees for propagation work, to determine the effect of bud selection in relation to tree growth and yield, and to determine the relation between scion or bud and the seedling stocks. Although the work has not been carried on long enough to show conclusively the effect of bud and root selection on ultimate yield, the results are of interest from the standpoint of nurserymen and propagators.

Reciprocal Grafting Experiments

In the fall of 1921, piece roots were selected from a number of productive and unproductive Ben Davis trees. During the winter, scions were selected from these same trees, and from other pairs of high and low yielders. Grafts were made using various combinations of piece roots and scions as indicated in Table I. The grafts, which were set in nursery rows in the spring of 1922, made little growth, and even in 1923 few trees exceeded 70 cm. in height. The waxed string used in wrapping the grafts was too large to rot readily, so considerable binding at the union of the graft has occurred. Even though the piece roots and scions from old trees have given unsatisfactory growth and a large proportion did not grow, the grafts have at least had uniform treatment. Table I shows the row and tree number from which the roots were obtained; the total yield of the trees for the 5 year period, 1914-18 inclusive; the row and tree number of the trees from which scions were selected; the 5 year yield of these trees; the number of grafts

*Paper from the Biological Laboratory, Maine Agricultural Experiment Station, No. 161.

which survived; and the size of the nursery tree in units obtained by multiplying height by caliper.

TABLE I

Showing the Source of Piece Root and Tree Yield, Source of Scion and Tree Yield, and the Size of the Nursery Trees in 1923. Size Units Obtained by Multiplying Height by Caliper

Ben Davis Grafts

Root from	Yield tree 1914-18 inclusive	Scion from	Yield tree 1914-18 inclusive	Number of grafts	Mean size in units	D / P. E.
9-11	1091	9-12	196	27	372±24	5.2
9-12	196	9-12	196	17	171±15	
9-12	196	9-11	1091	22	202±17	7.3
9-11	1091	9-11	1091	29	500±37	
9-4	427	8-7	170	25	172±23	4.3
9-3	2	8-7	170	7	57±14	
9-3	2	8-6	661	24	65±5	7.7
9-4	427	8-6	661	32	188±15	
17-2	190	17-2	190	22	361±39	2.4
17-1	586	17-2	190	29	255±20	
17-1	586	17-1	586	32	242±16	6.5
17-2	190	17-1	586	34	431±24	
3-2	143	24-2	649	18	305±34	1.1
3-3	394	24-2	649	28	259±25	
3-3	394	24-1	33	18	361±24	2.5
3-2	143	24-1	33	18	280±21	

In the first and second series of reciprocal grafts, the piece roots from productive trees gave much better results than roots from unproductive trees. These differences are significant, as indicated by the values obtained by dividing the differences in size by the probable error of this difference. In the third series, the condition is reversed, the roots from the unproductive trees giving the best results. The difference is significant in only one of the two combinations, however, since the roots grafted with scions from tree two, row 17, have a difference in size of less than three times the probable error of the difference. The difference in behavior of piece root selections in the fourth series is not significant. Although the differences in roots from productive and unproductive trees are not consistent in their behavior when grafted, there is a striking difference in the behavior of piece roots from different individuals, which may indicate inherent differences in vigor, or compatability. It is perhaps significant that where the parental trees differed greatest in performance, the selected roots also differed consistently in accord with parental behavior.

There is some indication that scion selection may have some effect on the growth of the progeny. In the first series scions from 9-11 and 9-12, when worked on roots from 9-11, resulted in two year old trees with a mean size difference of 128±44 units.

The difference is 2.9 times the probable error and is of questionable significance, especially in view of the fact that the scions from 9-11 and 9-12, when worked on roots of 9-12, gave a difference in size of trees only 1.4 times the probable error. A similar effect of scion selection is found in the fourth series, but even if the differences were significant, scion selection results in small differences in tree growth, as compared with the results of root selection.

Bud Selection

In the spring of 1922, 2,000 number 1 American grown French crab seedlings were purchased from a wholesale nursery company and set in nursery rows at Highmoor Farm. About two-thirds of these trees were budded in August, 1922. Buds were selected from pairs of productive and unproductive trees growing in various commercial orchards, and in our experimental orchards. Where possible the yield or tree size of the parental tree was obtained. The McIntosh and Delicious trees were about 12 years old when bud sticks were cut. The yields of these trees were estimated by owners, but the trunk girth is a good check on productivity. The Ben Davis and Northern Spy trees were about 30 years old and yields are from our own records.

The fact that the French crab seedlings are variable in size, vigor and perhaps compatibility, makes little difference in the mean size of nursery stock grown on such roots, because if sufficient numbers are used, the effects of random sampling will eliminate chance differences in roots for any class of buds. The effect of random sampling was verified by obtaining the mean seedling size and standard deviation for each class of buds.

The source of buds, productivity of parental tree as indicated by yield or size, and mean caliper of the whip in mm. is shown in Table II. A rather large percentage of the buds failed to grow, but there is no consistent difference in death rate between buds from productive and unproductive trees. In two cases the buds from large productive trees produced whips significantly larger than buds from unproductive trees, although the differences are not large. In case of the first pair of Delicious (selection numbers seven and eight) the odds against such a difference being due to chance, is 175 to one. Random sampling was effective in smoothing out differences in size of the seedlings on which the buds were grafted, as indicated by the mean caliper of seedlings of $9.51\pm.12$ and $9.59\pm.10$, respectively, and the standard deviations of $1.34\pm.08$ and $1.33\pm.07$, respectively, for the two classes of seedlings. In the second pair of Delicious selections, the tree classed as unproductive is probably inherently more productive than the tree classed as productive, since the trunk caliper is greater, but it is apparently slower in coming into full bearing. The difference in bud performance in this case is not significant. In case of the Ben Davis and Northern Spy selections there is no significant difference in performance of buds from productive and unproductive pairs of parental trees. A comparison of the progeny from the two pairs of Ben Davis trees does indicate, however, that all differences may be due to environmental factors rather

TABLE II

Showing Performance of Trees from Which Buds were Selected, the Number of Trees Budded, and the Mean Size of the One Year Old Whips

Selection Number	Parental tree	Parental yield	cm. Trunk circumference	Number trees budded	Number buds grew	Mean caliper of whip, mm.	Difference P. E.
1	+McIntosh	±12 barrels 5th-10th year	...	98	78	9.13±.17	—1.3
2	—McIntosh	+ 1 barrel 5th-10th year	...	100	83	[illegible]	
3	+McIntosh		...	98	79	9.38±.16	[illegible]
4	—McIntosh		...	51	42	8.62±.19	
5	+Ben Davis	1060 pounds 1914-18	79	97	85	9.71±.14	+ .005
6	—Ben Davis	34 pounds 1914-18	53	98	84	9.70±.13	
7	+Delicious	3 barrels 1921	54	83	72	9.14±.14	+4.1
8	—Delicious	1 bushel 1921	29	85	74	8.28±.15	
9	+Delicious		29	81	73	8.84±.15	—1.6
10	—Delicious		40	64	54	9.19±.16	
11	+Ben Davis	1091 pounds 1914-18	81	73	66	9.17±.14	+1.1
12	—Ben Davis	196 pounds 1914-18	63	82	69	8.96±.13	
13	+Northern Spy	3400 pounds 1914-18	116	137	123	9.89±.13	+1.1
14	—Northern Spy	170 pounds 1914-18	68	69	66	9.64±.18	

+=productive. —=unproductive.

than bud mutation. Although the productive and unproductive Ben Davis trees of each pair vary greatly in yield, there is no significant difference in performance of buds within each pair. There is, however, a difference of nearly four times the probable error between the size of the progeny from the unproductive trees of each pair, and a difference of almost three times the probable error between the size of the progeny of the two productive Ben Davis trees. These results can not be attributed to differences in size of seedlings because the effects of random sampling were checked and no significant differences were found in size of seedlings, although selection numbers 11 and 12 were budded on slightly larger seedlings than were selection numbers five and six. The uniformity of seedling size shows that soil fertility does not vary greatly. Bud development in the spring of 1923 was more rapid in selections five and six, than in selection 11 and 12, and was perhaps due to greater reserve food in the buds. Selections five and six were from two Ben Davis trees which were top-worked in the spring of 1920, and which were cut back severely and fertilized heavily for two years before the buds were selected. Buds were of course selected from the old branches which had not yet been removed in top-working. Selection numbers 11 and 12 were reciprocally top-worked in 1922, but were not cut back severely and did not make as much growth as the first pair of parental trees. The behavior of the progeny of these two pairs of Ben Davis trees would indicate that differences in performance of selected buds can not be attributed to inherent differences in parental trees, although somewhat better results may be obtained by selecting buds from vigorous healthy trees. Whether these differences in growth will persist to maturity is of course questionable, but there is some indication that they may.

The Relation of Stock and Bud in Propagation

Although the French crab seedlings used were number 1 grade, they varied considerably in size, and varied from four to 13 mm. in trunk caliper. Each tree was numbered with a metal tag, and data recorded for a number of seedling and whip characters. Trunk caliper was obtained for each seedling several weeks after it was set, which gives the seedling size at the end of the growing season in 1921. The growth of the seedlings for 1922 as shown by terminal growth, varied from 12-80 cm. The buds on each bud stick were numbered consecutively from the base to the tip of the stick. The seedling caliper was obtained in the fall of 1922, after the trees were budded and was found to vary from five to 15 mm. On the 18th of May, 1923, the development of buds of the seedling, and the development of the grafted bud, was recorded. The stage of development was arbitrarily classed into five groups varying from buds completely dormant to those with leaves longer than 25 mm. The tops of the seedling trees were removed at this time. In the fall of 1923, the caliper of the one year old whips, was recorded. Correlations between these various characters were obtained for each of the four varieties budded. In correlating bud and seedling development with other characters,

the correlation ratio was used instead of the correlation coefficient, because of the arbitrary classification of development. The characters correlated with bud or seedling development, vary uniformly from one to five in the scale of bud or seedling development, as indicated by mean values of each array. The various correlations are shown in Table III.

TABLE III

Correlations of Various Characters of Seedling and Whip for Each of the Varieties Used

Characters correlated	Correlation coefficients			
	McIntosh	Ben Davis	Delicious	Northern Spy
Seedling caliper, 1921, with				
Seedling growth, 1922	.10±.04	.12±.04	.08±.04	.16±.05
Seedling caliper, 1922	.48±.03	.53±.03	.49±.03	.57±.04
Whip caliper, 1923	.13±.04	.04±.04	.05±.04	.22±.05
Seedling caliper, 1922, with				
Seedling growth, 1922	.59±.03	.50±.03	.55±.03	.55±.04
Seedling development, 1923 ...	—.14±.04*	—.13±.04*	—.20±.04*	—.11±.05*
Bud development, 1923	—.22±.04*	—.25±.04*	—.10±.04*	±.18±.05*
Bud number, 1923	—.06±.04	—.02±.04	—.06±.04	—.09±.05
Whip caliper, 1923	.36±.04	.38±.03	.26±.04	.43±.04
Seedling development, 1923, with				
Bud development, 1923	.05±.04*	—.08±.04*	—.26±.04*	—.11±.05*
Whip caliper, 1923	—.05±.04*	—.15±.04*	—.27±.04*	—.05±.05*
Bud development, 1923, with				
Whip caliper, 1923	.23±.04*	.23±.04*	.30±.04*	.59±.04*
Bud number with				
Whip caliper, 1923	—.10±.04	—.04±.04	—.13±.04	—.01±.05

*Correlation ratio.

The caliper of the seedlings when they were set in 1922 (1921 growth), is only slightly correlated with growth in the summer of 1922. Evidently one year seedling size is dependent largely on environmental factors, or the effect of transplanting largely eliminates any inherent differences. Seedling caliper in the fall of 1922 does however show a fairly high correlation with seedling size in 1921. Differences in seedling size when set in the nursery (within grade 1) had little effect on size of the whip in 1923.

Seedling caliper in 1922, shows considerable correlation with growth in 1922, a slight negative correlation with seedling and bud development, and considerable correlation with whip caliper. The correlation with bud number simply verifies the effects of random sampling. There is little or no relation between development of the seedling in the spring of 1923, and the development of the grafted bud. In fact, the Delicious buds developed somewhat earlier on the seedlings which developed latest in the spring. There is also a slight tendency in some cases for the seedlings which developed more slowly, to produce the best whips.

There is some correlation between the rapidity of develop-

ment of the grafted bud and its ultimate size at the end of the first growing season. This relationship is not dependent on seedling vigor, or seedling development, since there is, in general, a slight negative correlation between seedling size in the fall of 1922 and bud development, and little or no correlation between seedling development and bud development, or whip size. The rate of development of the grafted bud may be due to specific compatibility between the seedling and the bud, to technique of budding, or to differences in reserve food supply in the bud.

The correlation between bud number and whip caliper shows that in case of Delicious there was some tendency for the buds at the base of the bud stick to give slightly greater whip growth, but the differences are too small to be of any practical value.

Similar data were obtained in my own nursery of McIntosh trees, where both seedlings and whips were at least 50 per cent larger than those at the experimental farm. In this nursery, seedling caliper in 1922 correlated with whip caliper in 1923, gave a value of $r = .26 \pm .06$. Seedling growth in 1922 with whip caliper gave a value of $r = .29 \pm .06$. The seedlings which developed slowest in the spring of 1923, produced somewhat larger whips than those which developed early, as shown by the correlation of $-.24 \pm .06$. Bud development with whip caliper gave a value of $r = .59 \pm .05$ and the same value for the correlation ratio. In this nursery, the factor or factors which cause early development of the grafted bud, are much more effective in controlling whip size than the size of the seedling. The correlation between seedling size and whip size would undoubtedly be larger if the seedlings were grown without crowding, budding without transplanting, and especially if a random sample of all sizes of seedlings were used. It is evident, however, that whip development, and perhaps, the size and productivity of the mature tree, are dependent not only on seedling size and vigor, but also on other factors which influence the time of bud development in the spring. Whether bud development in the spring is due to seedling compatibility, or budding technique, can be determined in another year.

Investigations in the Rooting of Apple Cuttings

By A. F. VIERHELLER, *University of Maryland, College Park, Md.*

INTRODUCTION

IF apple varieties could be propagated by cuttings, and thus be established on their own roots, directly, two great benefits would result: (1) variable stocks would be eliminated from experimental work and (2) Costs of propagation would be lowered by the practical nurseryman.

LITERATURE REVIEWED

This problem has been investigated from time to time by both

experimental and practical workers. A brief review of the literature shows the following results:

Shaw (1), of Massachusetts, in working with about 1000 cuttings, had one to strike root. Thomas (2), at the University of Maryland, claimed to have obtained a high percentage of rooted cuttings. Fagan (3), of Pennsylvania, who has worked on this problem for several years, has secured only a few rooted cuttings, after working with a large number. However, Fagan (3) states that Newman of South Carolina has written him that he has no difficulty in rooting quite large numbers of cuttings by burying them upright to the top bud in the open ground in the fall, and according to Shaw (1), Munson had no difficulty in rooting peach and apple switches plunged into the open ground in Texas.

Investigations in Maryland

This problem has been under investigation for several years at the University of Maryland. The present investigations have covered the past two years. In this work the influence of heat, moisture, light, air, an acid medium, and a stored food supply on the formation of roots, have been studied. These are merely relative terms, and have little bearing upon the interpretation of the results, as one phase of environment was affected by several others. For instance, the effect of bottom heat on cuttings placed in the greenhouse bench, was not separate from the effects of moisture, aeration, or light.

Outline of Experiments, First Year's Work

In the first year's work, the following materials were used:

A. Ungirdled terminals of various varieties.

B. Terminals which had been girdled during the summer.

The ungirdled terminals were given the following treatments, or combinations of these treatments.

1. Tops coated with paraffin or not coated with paraffin.
2. About three inches of basal part of cutting scraped in various places to cambium.
3. About three inches of basal bark slit in several places.
4. Leaf scars on basal three inches of cutting injured, with knife point.
5. Strips of bark removed from basal part of cutting.
6. Callus at base of cutting nicked.
7. Checks, not treated.
8. Buds on basal three inches of cutting removed.
9. Buds on basal three inches of cutting not removed.
10. Cutting newly trimmed at base.
11. Basal three inches of cutting coated with lamp black.
12. Basal three inches of cutting coated with manganese dioxide paste (with water).
13. Long whips cut into two pieces.

The girdled terminals were given treatments, or combinations of treatments as shown under 1 to 7 inclusive. In addition, some received the following treatments:

14. Soft, green wood cuttings cut square at base.
15. Soft, green wood cuttings, heel cut.

16. Soft, green wood cuttings, cut diagonally through old and new wood.

The above cuttings were placed under the following conditions:

a. Base of cutting in moist sand with bottom heat.

b. Base of cutting buried in sand with bottom heat, tops kept cold.

c. Set in flasks partly filled with water. Some flasks darkened, others exposed to light.

d. Set in black soil in warm greenhouse.

Material was collected from trees of the following varieties:

Red Astrachan, Gano, Bloomfield, Smokehouse, Delicious, Stayman Winesap and a seedling tree. The trees ranged in age from eight to 24 years, all in good vigor, practically free from diseases, and grown under conditions of cover crop and clean cultivation for several years.

The ungirdled terminals used in the first year's work were cut from the trees during the period between December 15, 1921, and January 4, 1922. The one year terminals, or scions, were cut off at the base of the bud scale scars. Each terminal was trimmed with a sharp knife "at the node," or the first well-developed bud above the base.

The girdled terminals used in the first year's work were girdled August 4, 1921. The girdle was made by removing a ring of bark about one-fourth inch wide at the base of the bud scale scars. These terminals were cut from the tree December 12, 1921. All material was placed in moist sand in a cool cellar to callus, until the experiments were begun.

Investigations with Ungirdled Terminals

Fifty ungirdled terminals each of Gano and Red Astrachan as treated under 1 to 8 were placed in a sand bench, February 6. To inhibit bud growth on that part of the cuttings above ground, one-half the number of cuttings used were coated with paraffin. However, no increased action at the underground part of the cuttings occurred and in 66 days all cuttings had died.

The effect of keeping the tops cold and warming the bases of cuttings was investigated by burying cuttings in a box of moist sand, thrust through a greenhouse wall, so that the bases of the cuttings were over hot water pipes, while the tops were in partly frozen sand outside. Forty cuttings each of the Gano and Red Astrachan, both girdled and ungirdled, were used, and removal of basal buds, and use of callused and uncallused cuttings, gave no results. All rotted in 55 days.

To see if the absorption of light would influence the formation of roots on cuttings, due probably to increased temperature, the bases of 30 callused cuttings each of Gano and Red Astrachan were coated with manganese dioxide paste, using an equal number coated with lamp black paste, also a number of untreated as a check. These cuttings were set three inches deep in flasks partly filled with water, and set upon a shelf in a greenhouse exposed to full sunlight. After 101 days all had died, and the results, if any, were an increased callus on the untreated twigs.

Tests with Fertile Soil

The effect of black, fertile soil as a heat absorber and a fertile medium, was tested out by the use of 40 cuttings each of Gano and Red Astrachan, placed about three inches deep in pots and set in a warm, sunny greenhouse. The use of callused and uncallused cuttings as well as the removal of buds beneath the soil surface gave no results and all cuttings died.

Terminal Versus Basal Part of Cuttings

It was noticed during these investigations that vigor of callus formation seemed to have no correlation with the size or vigor of cuttings, so that the formation of callus in various regions of the cutting became of interest. On December 10, vigorous seedling apple terminals, or whips, about 16 inches long were taken from the trees and after being cut in half, were stored in moist sand. These were removed and 20 pieces of each half were set in the sand bench, February 18, checking the bases of the whips against the terminals. The buds beneath the sand surface were removed from half of each lot. By May 8, 79 days later, 18 of the cuttings were dead, while one terminal and one basal cutting had rooted. In both cases, the basal buds had been removed, but this apparently did not affect the rooting process. Roots were very brittle. Whether the two rooted cuttings were originally of the same piece is not known.

The rooting tendencies of water sprouts were similarly tested out, as above, using Smokehouse, but in 39 days after setting in the bench, all had died.

Investigations With Girdled Cuttings

Twenty-one vigorous terminals of Delicious girdled August 5, 1921, stored December 12, 1921, were placed in the bench March 1, 1922.

One cutting, nicked at callus, had developed a root about five-eighths of an inch long, by May 11, (72 days). While some cuttings died without showing any unusual results, it is of interest to note that five of these cuttings are still living without roots after 21 months in the bench, and are still showing feeble callus development and pushing out an occasional, but very small rosette of leaves.

Soft Wood Cuttings

The possibility of using soft wood cuttings was investigated by obtaining cuttings from Gano and Red Astrachan on May 5, and August 5, 1922. The types of cuttings used were as follows: Cut square at base of new growth; "Heel cut;" cut diagonally through old and new wood.

No definite results were obtained, but it was found that late summer cuttings lived longest. It is interesting to note that four of the cuttings are still living and putting out small rosettes of leaves after 16 months in the bench, yet have no roots.

Second Year's Work. (1922-23—All Terminals Girdled)

Current season's terminals of Gano, Red Astrachan, Stayman Winesap and seedling varieties, were girdled May 22, June 25, and August 13, 1922, cut during December, stored in moist sand

and treatments begun February 17, 1923. The treatments given were: basal bark scraped; basal bark slit, and callus nicked; cuttings set 24 hours in one per cent $KMnO_4$, then set in bench; check not treated. All tops were paraffined.

Of the 434 cuttings of all varieties used in this year's work, five had struck root by May 11, about 83 days after setting in the bench.

Cuttings that rooted had been treated as follows:

1 Seedling—Basal bark scraped to cambium, in places. Girdled May 22.

1 Gano —Slit bark, nicked callus. Girdled August 13.

1 Stayman Winesap—*Covered tree—slit bark, nicked callus. Girdled August 13.

1 Stayman Winesap—*Covered tree—bark scraped to cambium in places. Girdled August 13.

1 Stayman Winesap—*Covered tree—no treatment. Girdled August 13.

In those cuttings where roots were formed the roots developed from the lowest bud which closely adjoined the callus as shown in Figure I.

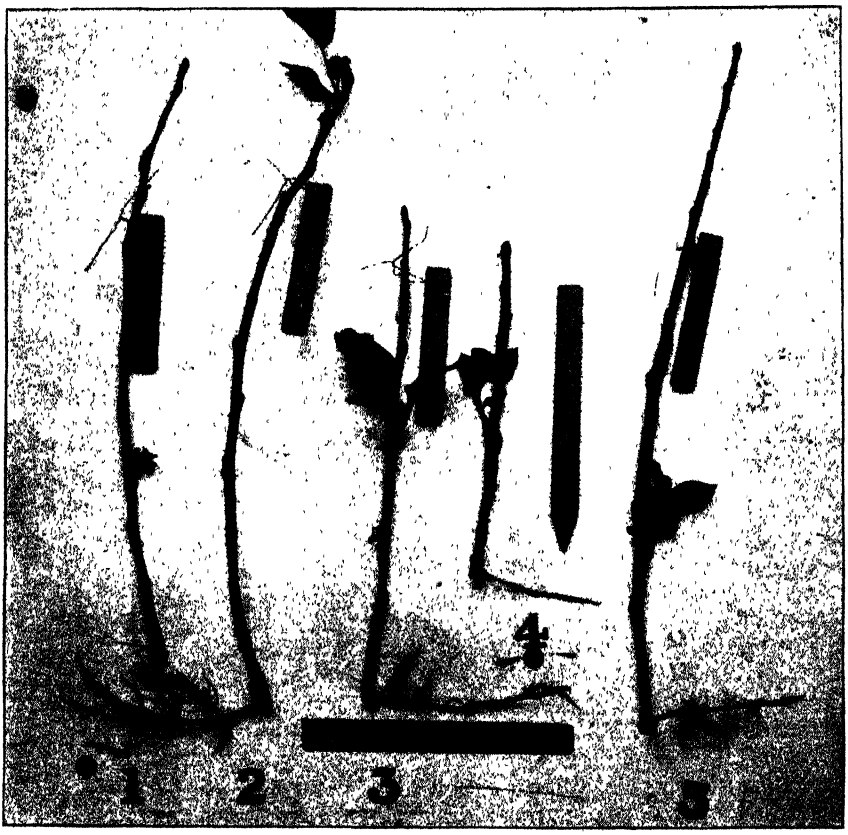

Figure I—Roots developed on hard wood cuttings on the apple.

***This tree was enclosed in a tight, heavy muslin frame at time blossom buds showed pink. Cover removed August 12.**

Acid Treatments

From reading various articles on the rooting of plants in general, the idea was suggested that possibly cuttings would form roots more readily in a slightly acid medium.

Accordingly, on March 26, 1923, 1000 ungirdled cuttings which had previously been callused, were planted in quartz sand in flats. Each flat contained 250 cuttings.

Acetic acid solution of Ph3.0, Ph3.5, Ph4.0 and Ph4.5 were made up, and one flat was watered each day with Ph3.0, one with Ph3.5, one with Ph4.0 and one with Ph4.5 for a month, tap water being substituted after that time. One Stayman Winesap cutting in the Ph4.5 group had rooted by July, all others having died.

General Summary

After two years of investigation, though nine cuttings of four different varieties have rooted, no one treatment has given consistent results.

Further investigations, using terminals from trees which have been shaded all season, are under way at the present time.

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Symposium on Crown Gall Inspection

By M. J. Dorsey, *University of West Virginia, Morgantown, W. Va.*

THE paper which Dr. Dorsey, representing our society, read in the symposium, together with the papers read by the speakers from other societies, will be printed as a pamphlet by the American Association of Nurserymen. As a result of this symposium the speakers and Professor F. C. Stewart composing an inter-society committee on crown gall inspection met and adopted the following report:—

1. Owing to the wide distribution of *Bacterium tumefaciens*, the large number of its host plants, and the difficulty of detecting all affected plants, official inspection of nursery stock for the purpose of preventing the dissemination of the crown-gall organism, is unwarranted. The sole object of crown-gall inspection is to prevent the sale and planting of stock which will not produce a normal crop. If it be assumed that all plants affected by crown-gall are unfit for planting, no method of official inspection is adequate protection for the planter, because of the nature and wide distribution of the causal agent. Inspection regulations should be framed with these things in mind and a clear distinction should be made

between crown-gall and malformations due to excessive callusing, cultivation injury, woolly aphis, and nematode injury.

2. The amount of injury done by crown-gall varies greatly with different species of plants and, in some cases, even with different varieites of the same species. Also, it appears to vary somewhat with the character of the soil, methods of culture, and climatic conditions. Accordingly, it is impracticable to have uniform inspection regulations for all kinds of plants, or for all parts of the United States.

3. In each state the extent of the injury done by crown-gall to the principal economic plants grown in the state should be accurately determined and the findings used as the basis of inspection regulations. Generally speaking, the persons best qualified to do this are the plant pathologists and horticulturists of the agricultural college and agricultural experiment station. They should be consulted freely by those in charge of nursery inspection.

4. In general, the injurious effects of grown-gall have been overestimated, particularly in the case of the apple. Crown-gall injury is least pronounced in the northern and northeastern portions of the United States.

5. Crown-gall inspection regulations should describe fully, and as accurately as may be possible, the symptoms shown by plants to be rejected. To say that "all plants visibly affected by crown-gall will be rejected," is not sufficiently explicit. Hair-splitting methods of inspection are unnecessary and should not be permitted. Considerable tolerance should be allowed.

6. Field inspection for crown-gall is unreliable. The only worthwhile inspection is that made at the packing shed, or at the point of destination.

7. Except as a penalty for law violation, the rejection of an entire shipment because some plants in it are affected by crown-gall, is unwarranted.

8. In view of the foregoing it is recommended that this Society solicit the active cooperation of the American Association of Nurserymen in a research program that will ultimately answer the questions now involved, directly and indirectly, in a better understanding of the nursery inspection problems relating to crown-gall.

Respectfully submitted,

F. C. STEWART
I. E. MELHUS
M. J. DORSEY
H. F. DIETZ
H. B. CHASE

Committee.

Seventy-Five Years of American Horticulture

By J. H. GOURLEY, *Experiment Station, Wooster, Ohio*

IT is 75 years since the American Association for the Advancement of Science was founded, and it has been suggested that the various sections of that body together with the associated societies, take some note of the occasion. It will be the purpose of this paper, therefore, to trace briefly the progress of horticulture in America during the past three-quarters of a century. But it must be made clear at the outset that not all of even the important landmarks, can be listed, or treated, in a paper of this length, for man after man and event after event form a mosaic without break during this period in which much of the foundation of our art and science, has been laid. A retrospect allows us to examine the trail of our travels, to set up some stakes and sight across the span of years and see where we stand today in comparison with our position in 1848. It permits us to consolidate the ground gained, to appreciate the foreworkers in our field, and should give us inspiration for the tasks ahead.

While horticulture in the minds of many, represents the aesthetic, the beautiful, and perhaps some might add the peaceful in the realm of agriculture, it is by no means such a restful picture when we scan its development. There were aggressive and staunch leaders, there were belligerent souls that fought no mean fight in the face of ridicule—that most ready weapon of one's opponents—to establish what are now commonplaces in our field of knowledge.

But let us realize that to go back 75 years is to return to the dark ages, so far as agriculture is concerned. There had been no advance excepting to extend the domain. The nature of plant disease was not understood until in the 80's, agricultural chemistry was just dawning on the horizon, no improvement had been made in a mechanical way, and the farmer sowed his grain broadcast as was done from the beginning of time. He cut it with a sickle and threshed it with a flail. The moon, the stars, and St. Patrick's Day, governed practice. Agricultural education had scarcely been suggested and horticulture was a rich man's fancy. But, nevertheless, this is a suitable period at which to start an epoch, and if some of the notions of that day seem primitive, let us remember that the present status of basic truths is far from complete, notwithstanding the incomparable opportunities for training and work, and the equipment provided.

THE ERAS

In attempting to divide these 75 years into epochs, it was decided to denominate the period from 1848 to 1880 as the Amateur Era characterized by a study of nomenclature and synonymy of fruits; from 1880 until 1900 as the Era of Variety Testing and Miscellaneous Field Experiments; and beginning with 1900 or roughly coincident with the passage of the Adams Act, the Era

of Research. I think a careful scrutiny of the outstanding thought of those times will justify some such division.

The Amateur Era, 1848-1880

In the year 1848, we find a list of distinguished horticulturists, too numerous to mention personally, some of whom were celebrated both at home and abroad. We might refer to this as the Downing Epoch of the Amateur Era, not because either of the Downings were better informed, or made a greater contribution than others of their time, but because of the classical writings, personal influence, and breadth of interest of A. J. Downing, together with his tragic death, which caused him to be immortalized in the minds of his contemporaries. The influence and contributions of such men as Barry and Charles Downing, Henderson, Hovey, Longworth, Thomas, Warder, and Wilder, cannot be measured. Among them we find some masters of the art of horticulture; some clear thinkers along somewhat technical lines; some who represented the philosophy that characterized the age; some who possessed the dignity and culture that the craft needed; as well as many who fostered the erroneous notions and inaccurate observations that were rampant in that day and that have been handed down to the present time.

It would be particularly difficult to estimate the influence of Marshall P. Wilder, a man who had *entree* to all classes of society and seemed to be the one man who could breathe a soul into the struggling and unfolding industry and philosophy—we can scarcely say science—of horticulture. He was a vital force in the establishment of the Massachusetts Agricultural College and later in promoting the agricultural and horticultural work of the Government and the securing of Federal aid for agricultural colleges. In this connection, I would like to refer to the history and influence of the Wilder Medals in encouraging and recognizing meritorious fruits and accomplishments, as depicted by Professor C. P. Close in the Report of the American Pomological Society for 1923.

These men created an era and a most important one. Pomology was by far the outstanding horticultural interest of the time and the leaders in the industry recognized a hopeless confusion in the nomenclature of most of the fruits, and the synonymy was "confusion worse confounded." For instance, a writer in 1875 speaks of 29 varieties of apples with 370 names! It was a period when enthusiastic amateurs, and to a considerable degree those who may be classed as commercial orchardists, sought to obtain every variety then known, to add to their collections.

Not only were the existing varieties tested for their quality and an attempt made to unravel the confused nomenclature, but new sorts were constantly introduced from Europe, and new American seedlings of merit shown and introduced to the trade.

All this activity brought together the best minds and ardent enthusiasts, and it is little wonder that we find an epidemic of horticultural or pomological societies coming into existence. The New York Society in 1818 seems to be the first, but was short lived; Pennsylvania followed in 1827; Massachusetts in 1829; Kentucky

in 1840; Indiana in 1842 (which soon died), a later society was formed in 1860; Rhode Island in 1845; Delaware in 1847; Ohio in 1847; and others followed in rapid succession.

Since what may be termed the parent society of our own organization came into being 75 years ago, the year which we are commemorating, a few notes regarding it are in place.

American Pomological Society

This organization has long held the distinction of being the highest authority in this country on pomological matters. So great was the need of such a society that its origin seems almost spontaneous, as we view it from the distance. With an able group of men, and with a great work to be done it is little wonder that the common need should have brought them together for the task. We, of the present, salute them and hold in highest regard their achievements.

In 1848 was laid the foundation of this society by the independent meetings of two groups of fruit growers. The one group met in New York City, October 10, at the call of The American Institute, and was composed of representatives of the horticultural societies of Massachusetts, Pennsylvania, New Jersey, and New Haven. This convention adopted the title of the American Congress of Fruit Growers. The other group met at Buffalo in connection with the New York Agricultural Society under the name of the North American Pomological Convention. In 1849 both met in New York City and united under the name of the American Pomological Congress. The next meeting of the Congress was held in Cincinnati in 1850, and the next in Philadelphia, where a constitution and by-laws were adopted and the name was changed to the American Pomological Society. Mr. Marshall P. Wilder was elected president and served in this capacity until his death in 1886. Its Constitution stated that "Its object shall be the advancement of the science of Pomology."

It would seem unfortunate to us that so much time was spent by them in varietal discussion. It became the vogue and lasted many years and hence we do not find any scientific advance during this era worthy of the name, although such men as Thomas, and Barry, were thinking along technical lines. But the outstanding contribution of this organization was in clearing up nomenclature, or we might say, systematic pomology, and in discarding worthless varieties of fruits by the hundred. But this Society also served as a clearing house for all sorts of horticultural information, and directed the variety trials that became the dominant feature of our next era. Also, individually, and as a society, they were an inspiration and stimulated horticultural pursuits, and they worked for the establishment of agricultural colleges and experiment stations.

Prevailing Notions

But let us look for a moment at the prevailing notions of the times; whether they came from Europe, or were observations gleaned from American practice, matters little.

In 1847, a prominent chemist discussed what was probably late blight of the potato as follows: "The cause of the disease is the same which in spring and autumn excites influenza, that is, the disease is the effect of the temperature and hygrometric state of the atmosphere, by which, in consequence of the distribution of the normal transpiration, a check is suddenly, or, for a considerable time, given to the motion of the fluids, which is one chief condition of life, and which thus becomes insufficient for the purpose of health, or even hurtful to the individual."

Apple and pear blight was a leading subject for discussion at horticultural gatherings and its cause was variously assigned to frozen sap, microscopic insects, a Providential judgment on the grower, and other hypotheses.

The most spirited controversy of this time was that which has been termed the "Strawberry war." We are familiar with this bit of history, but let me cite the findings of a committee of the Cincinnati Horticultural Society as an example of error in what is now a commonplace fact. "There is no such thing known to us as a perfect flowering strawberry plant in which the blossoms will all be uniformly so well provided with both sets of organs as to be followed with perfect fruit every year." But the contention of the celebrated Bostonian, Hovey, that all strawberries are self-fruited unless they degenerate through culture, was exploded, and the main postulate of Longworth that there are pistillate varieties that require perfect flowering sorts near them for the purpose of cross-pollination, was fully vindicated. The error was corrected by themselves toward the beginning of this era, much to their credit.

May we consider briefly the notions on orchard fertilization, if the views of A. J. Downing may be accepted as fairly representative of his time. He contrasts the past by saying that 20 years before not one person in 10,000 would have used anything beside barnyard manure to enrich the land, while in 1848 every intelligent farmer was familiar with the value of "muck, ashes, lime, marl, bones, and a number of less important fertilizers." He recognized the irregularity of orchard production and the lack of knowledge regarding its regulation. "Every experienced orchardist, he says, is familiar with these things but no practical cultivator has the explanation ready." Doubtless he little suspected that it would be nearly 70 years before well conducted experiments would begin to offer satisfactory explanations for the erratic behavior of orchards. He hopefully looked to the development of agricultural chemistry that was just then looming, for the explanation, for he considered it would be found in the soil. He cited chemical analyses of the wood and bark of apple, pear, and grape, and says: "No intelligent cultivator can examine these results without being conscious at a glance that this large necessity existing in these trees for potash, phosphate of lime, and lime, is not at all provided for by the common system of manuring orchards," and recommends potash and bone dust for pear trees, lime as the outstanding essential for fertilizing apple trees, and potash for the grape. Furthermore, he says, "Hence it is not unlikely that certain diseases of fruit, known as the bitter rot in apples, the

mildew in grapes, and 'cracking' in pears, may arise from a deficiency of the inorganic elements in the soil.'' Illuminating illustrations are given to fortify these conclusions and he states that many more could be cited!

Or, if we consider the impressions current in 1852 regarding the nature of the buds, spurs and shoots of the tree, we find that it is no longer necessary to consider a fruit bud as an exotic in the economy of the tree, ''a sort of parasitical plant living at the expense of the wood system'' and ''in a state of antagonism with it.'' Nor is ''its appearance at the extremities of leading branches, an evidence of over-fruitfulness and disability if not disease.''

Literary Contributions

But if all this appears like the dark ages it must be remembered that some notable literary contributions characterized the period. The classic writings of A. J. Downing in The Horticulturist, Fruits and Fruit Trees of America, and Rural Essays ,had a wide influence on rural architecture, landscape, and rural culture, in general. Hovey's Magazine of Horticulture was of a high order and left an indelible imprint on his generation. Thomas' Fruit Culturist (1846) was a torch of light in a dark period. The art, practice and variety question were ably treated and this volume in its many editions was used as a text book for orchardist and student over a longer period of time than any other.

Cole's American Fruit Book, Barry's Fruit Garden, Elliott's Fruit Book, and a little later Warder's American Pomology, together with Henderson's Gardening for Profit, typify the literary efforts at the opening of this 75 year period. From across the Atlantic came a volume that left its imprint on the minds of the horticulturists as on everyone else—Darwin's Origin of Species—and it must here be noted although not of American production.

The number of periodicals, books, and societies, that appeared at this time are but an index of the rapid extension of the industry. The years 1848-58 may be taken as witnessing the beginning of commercial orcharding in the United States and Canada, and as marking the extensive development of the nursery business although both had been growing for 50 years. The 70's saw the rise of commercial floriculture and the Society of American Florists was organized in 1884. Strawberry growing was so stimulated by the introduction of the Hovey and Wilson that the decades of 1850 and 1860 witnessed what was popularly termed the ''Strawberry fever,'' but there was a strong reaction during the next decades. During the 70's and 80's the Russian Fruit Introductions were at their height due to the activities of the United States Department of Agriculture and certain individuals which resulted in the securing of a few good fruits, but in the main was a fiasco.

Organization

As we trace the epoch-making events in what may be termed the category of organization, we find as already alluded to—the incipiency of the American Pomological Society in 1848; the Morrill Act in 1862 establishing the colleges of agri-

culture and the mechanic arts in the several states, and the organization of the United States Department of Agriculture in the same year. The establishment of the agricultural college had the most far reaching effect of any event to which we can point, because subsequent Acts of Congress relative to agriculture came as a result of this one. The Morrill Act was difficult of attainment and when once established there was woefully little to teach because the years before had been marked by a dearth of scientific accomplishment. The organization of these agricultural colleges included only one teacher for agriculture and horticulture while Latin, Greek, mathematics and several other branches were provided, and often with assistants to those professors. In addition, the professor of agriculture was charged with running a farm to make it pay, and then the funds were used for college maintenance; he was also in charge of the campus, and had many non-professional duties. Unfortunately, traditions last long! The reaction was not favorable to the college of agriculture and the progressive leaders insisted that the practical phases be strengthened. This was eventually done, and now today the trend is decidedly toward an era of a study of fundamentals, realizing that college is no place to make a practitioner if he is not already versed in the art; and low and behold our support in this comes from the place we least expected to find it—from the farmers and horticulturists themselves! Thus can we measure our progress.

Era of Variety Testing, 1880-1900

So much time has been spent in trying to reproduce just a little of the "atmosphere" of the middle of the last century, in order to secure a contrast with the present, that we must pass over the next era with only a word. As the Hatch Act establishing experiment stations brought into existence permanent machinery for research in horticulture, we find several practices taking form that have made possible the greatest horticultural development found anywhere in the world. We will not attempt to argue how much the stations had to do with them; they did, in our opinion, furnish the stimulus and considerable of the information for much of the development. The scourge of San Jose scale, the ravages of the Colorado potato beetle and codling moth, together with certain of the fungous diseases, resulted in the development of modern spraying. The development of cold storage in the 80's may also be mentioned although it was initiated by commercial concerns. The discovery of the blight bacillus and the explosion of the notion of the spontaneous nature of disease in general, were epoch making.

In the 90's, we see the dawn and it must be traced directly to the Hatch Act. Waite's work with pollination marked a real beginning and it has been followed for 30 years with additions to our knowledge of the perplexing pollination question and sterility. The time and details of fruit bud formation were investigated for the first time, and fruit breeding work got under way. Bailey's Principles of Fruit Growing, Evolution of our Native Fruits, and other works, were volumes that were used in every college in the teaching

of horticulture. But, it must be said that this era of 20 or 25 years is typified by extensive and repeated variety testing of all sorts of horticultural plants, particularly fruits and vegetables, and little else was attempted by many workers. Again, it was the vogue, had merit, and lasted a long time. The criticism is, that we did little else.

Beginning Era of Research, 1900

This era probably begins somewhat later than 1900, or as I have said before, roughly with the passage of the Adams Act in 1906.

By this time the industries are formed, and it is now a matter of growth and adjustment to economic conditions. Practices are pretty well established, mechanical appliances in the nature of power sprayers, sizing machines, packing house devices, etc., have been invented and improvements are appearing; the relative merits of the Baldwin and Ben Davis have been decided, and the deck would seem to be clear for something else.

The year 1900 marks the beginning of the science of Genetics, a line of work that has had a large influence in molding the science of horticulture. Mendelism rediscovered and the Mutation theory as a working postulate formed the basis for a tremendous amount of horticultural endeavor. Much has been learned, but we need more in the way of inheritance laws of fruits. Once as clearly established as with certain other plants, we may expect signal progress and the variety question takes on a new role.

Ask the composite fruit grower: what do you want, and what do you want to know? He replies: still better varieties; those that will bloom late and not be injured by frost; blight free pears; disease free fruits of all sorts; hardy fruits for all sections; something to take the place of the Baldwin; a conclusion with evidence behind it on the fruit stocks situation; what kind of a storage must I have; and so the categorical replies might be catalogued. He properly looks to the experiment station for this service and who dares say that we are not already on the road to these achievements, and that it is not due to an understanding of inheritance laws, and physiological principles, the which are due directly to research largely since 1900!

Passing on to the decade of 1910-1920, the research accomplishments begin to fill the pages of our journal that formerly contained much material of a Farmers' Institute caliber. Orchard fertilization is restudied and 75 per cent of the previous misunderstanding is cleared up and practice is almost completely changed. One of the outstanding practical accomplishments of the stations during this period was the discovery of the uses of quickly available nitrogen fertilizers. Let us not place this in a category of puerile effort, even though no principle was discovered. The nature of winter injury, hardiness, the rest period, and dormancy, are investigated, and the work is of a high order. Pruning is attacked from the viewpoint of the response of the tree to the treatment, both from a statistical and physiological standpoint, and as a result practice is radically changed and that gross error of heavy pruning which wrought so much mischief, is forever dispelled.

A study of the chemical changes in fruits during the ripening process and in storage give an intelligent basis for understanding certain practices in the future and is equally valuable to fundamental inquiry in pathology. Perhaps the greatest single contribution, by common consent, is that furnished by Kraus and Kraybill in laying down a nutritional basis of growth and fruitbud formation, this elusive and subtle problem that produced more mirages and fairy tales than any other single one in our field. As a result, many of our number have since and are now working on various related subjects of growth and fruitfulness. Soil studies aiming to explain tree responses and to throw some light on what is known as the "toxic theory," have been reported upon and are in progress. Some new studies of the effect of high and low light intensity and length of day on reproduction in horticultural plants, are contributing to a scientific foundation which the future can use for teaching plant response as a basis of further work. That many contributions of real merit have not been mentioned is all too evident to the writer, and the historian can fill them in in a more lengthy analysis of our progress.

An inspection of the official projects of the experiment stations for 1922-23, shows that horticulture ranks second in the number of projects listed. Of the 904 projects, apples lead with 118, and vegetables in general 58. Horticulture had the greatest increase of any subject matter department with 96 more than the previous year. There are approximately 376 men in part or wholly engaged in horticultural work in the state experiment stations.

I must mention another high point in the organization of horticulture in America and that is the Smith-Lever Bill creating the Extension Service. Not to make the research material available to the consumer in a way that he can appreciate and use it, would be like growing a crop of grain and failing to harvest it, and the station workers alone could not do this. There are over 76 men engaged in horticultural extension work, not counting the county agents or representatives of commercial or private concerns. The total amount of funds specifically appropriated for this work during the current fiscal year is about $319,497.00, according to Dr. A. C. True. Last year about $270,000.00 was specifically budgetted for horticulture as compared with $353,000.00 for agronomy; $312,000.00 for dairying; $254,000.00 for poultry; and $347,000.00 for animal husbandry.

Among the publications of this period may be mentioned the Standard Cyclopedia of Horticulture and the Fruit Books of New York which are culminations of horticultural knowledge that will stand for all time as monumental. We can only mention them in passing.

And lastly, a brief word regarding our own American Society for Horticultural Science, which, we may be pardoned for thinking, ranks second to none among similar organizations in the country. If it lacks some of the brass trimmings and tassels of some, it may take pride in the signal progress it has helped to stimulate, in the place its proceedings occupy among similar journals, in the fact that it has never had any friction within its organization, and that

today it is the critical clearing-house for the best in American Horticulture. Its views and sympathies are wide, it is conscious that its existence rests on a great industry, and yet it is distinctly a scientific organization. Organized in 1903 at the call of Professor S. A. Beach, and with Dr. L. H. Bailey as first president, it has met each year since. Its formation was a natural step in the development of the horticultural work in the country. The time was ripe for a society which would consider the scientific phases of the work and a great majority of the workers were in favor of it. If the next 20 years see as great a change and improvement in horticultural endeavor as the past 20, the agencies which support its workers may consider the effort worthy of the subsidy.

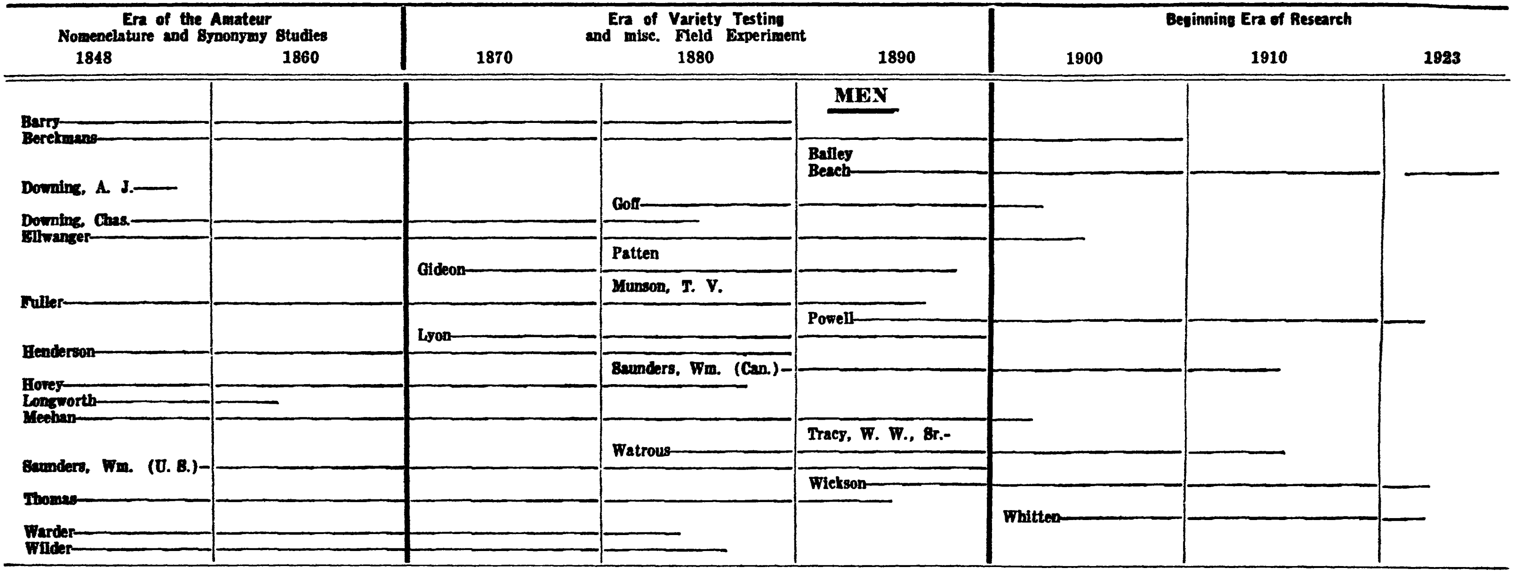
THE VIEWPOINT

It would be too much to hope that all would have the same viewpoint upon the function and type of work that devolves on the modern department of horticulture. To project a viewpoint, or try to express one's self is desirable, as it gives one's colleagues and administrative officials an opportunity to check it up with their own and correct error where it exists. In a science and art which are rather rapidly developing and evolving it is a serious handicap for any of its workers to maintain an obstinate and unyielding policy for it is within the realm of everyone's experience that new evidence and circumstances occasionally warrant a shifting of judgment. The writer is of the notion that an organization in both college and station should include individual workers who possess the best technical training that can be attracted, that a scientific atmosphere should be developed, fostered, and prized as one of its greatest assets. We may well recognize that it is only by extending our activities beyond the present frontier of knowledge that new ground can be won. And all this must be done while yet appreciating and in full sympathy with the art of horticulture, or, as it is frequently expressed, the practical. Lack of sympathy with such a program should not be tolerated, or an organization will be contented to dwell forever in the realms of the first two epochs depicted.

But along with this aggressive scientific viewpoint I believe a department of horticulture should also be represented by individuals who can stand on both feet in the front rank and be leaders in the art of fruit, vegetable, and flower production, be informed and be leaders in the great economic problems that face these industries. But here again such individuals should be well trained in fundamentals and in full sympathy with, and often partly engaged in, the more technical forms of inquiry. Such a balance in a department that represents a productive industry like horticulture will more nearly fulfill the mission that lies ahead.

We face some difficult problems, but our workers are increasingly better prepared, we have as our copartners those trained in closely related sciences. A spirit of mutual helpfulness prevails and one group no longer considers the other after the fashion of the proverbial son and mother-in-law. We have as a clientele enthusiastic supporters of high grade research, in the main, patient, hopeful, and confident. Such an outlook should be a stimulant and an encouragement to greater effort.

MEN, EVENTS AND NEW FRUITS: MILE-POSTS IN 75 YEARS OF AMERICAN HORTICULTURE



EVENTS

Organization	A. A. A. S. A. P. S.	Morrill Act Agr. Colleges U. S. Dept. Agr.		Hatch Act Exp. Stations U. S. Div. Pomology Am. Florist Soc. Exp. Farms—Canada		Adams Act A. S. H. S. Veg. Growers of Am.	Smith-Lever Act Extension Service U. S. Plant quarantine act.	
Literary	Rules of nomenclature Thomas' Fruit Culturist Fruits and Fruit trees of America	Catalog of Fruits American Pomology Warder Origin of Species Gardening for Profit Henderson	Barry's Fruit Garden		Principles of Fruit Growing Evolution of Native Fruits, et al. Bailey	Cyc. Am. New York	Horticulture Fruit Books	Fundamentals of Fruit Production Vegetable crops
Product's	Beginning of com'l orcharding in U. S. and Canada. Extension of nursery business		Rise of commercial floriculture	Rise of citrus industry Cal.	Rise of Western orcharding Tillage and cover crops	Co-op. Marketing Power Sprayers		
Sp. Events	Strawberry war "Strawberry fever"		Russian Fruit	Introductions Cold storage Refrigerator cars San Jose Scale Colo. Potato beetle Codling moth Bordeaux mixture Arsenicals	Introduction of spraying Lime-sulphur and oils			
Research				Discovery of blight bacillus Spontaneous nature of disease dispelled	Pollination and Sterility Time and details of fruit bud formation investigated Fruit breeding work	Science of Genetics Mendelism Mutation Rest period and dormancy studied	A nutritional basis of growth and fruit bud formation laid down (K+K) Orchard fertilization re-studied Pruning Nature of winter injury and hardiness Chemical changes in growth and storage of fruits Soil studies aiming to explain tree response involving toxic theory. New studies on light and length of day on reproduction.	

				NEW FRUITS			
Sutton Rome Beauty Wagener		Senator Stayman Winesap Banana Russian Fruits McIntosh		Delicious			Golden Delicious
Concord Delaware Rogers' Hybrids	Worden	Brighton Moore Early Niagara					
Early Crawford Late Crawford Lambert Howell Lawrence	Clapp Favorite Keiffer	Bing	Worden Seckel				
Sheldon Wilson Strawberry	Kalamazoo	Belle Georgia Crosby	Windsor Elberta Lemon Free Champion	Carman Greensboro Alton	J. H. Hale		
Houghton Gooseberry	Lincoln Clyman	Tragedy	Arctic Burbank	Wickson America	Hansen plums		
		Washington Navel Orange	Warfield Haverland Brandywine	Glen Mary Dunlap Marshall	Klondyke		
		Valencia Lemon Eureka	Gandy Bubach Aroma				

Effects of Oil Sprays on Fruit Trees

By A. M. BURROUGHS, *University of Missouri, Columbia, Mo.*

THE increasing use of lubricating oil emulsion against San Jose Scale in the last two or three years, has brought to the attention of horticulturists an old problem, namely, the likelihood of injury following the application of petroleum products to fruit trees. Before lime-sulphur came into general use, emulsions of kerosene or crude petroleum were used in concentrations of from 20 to 50 per cent on dormant trees. These sprays were applied at times with perfect safety, but at other times they proved to be harmful. The development of lime-sulphur between 1902 and 1910, resulted in the almost complete abandonment of the home-made kerosene and crude oil emulsions in the East and Middle West. Lime-sulphur, while somewhat more expensive, was effective in the control of scale, proved to be a powerful fungicide, and was not injurious when applied to dormant trees.

Nevertheless, certain petroleum sprays have been used to a limited extent in the past 20 years. Proprietary emulsions, known as miscible oils, have been on the market and have been applied since about 1905 with considerable success. In California, home-made emulsions of crude oil, or distillate, as well as proprietary emulsions, have been used considerably on both citrus and deciduous fruits to control scale insects and other pests. In the Northwest, the leaf roller has been successfully controlled in the last few years by the application of miscible oil. In England, Pickering (2) originated several types of emulsions with high boiling paraffin, and these oils have been used with considerable success since 1905. Emulsions of cheap lubricating oils (18) have been employed to control scale and mealy-bug on citrus trees in Florida since 1906, and these same sprays were tried out in 1921, by Ackerman (1) in Arkansas against San Jose Scale on apples. Since his work was made public, the engine oil emulsions have come into considerable use in the Middle West and may to a large extent replace concentrated lime-sulphur as a dormant spray on deciduous fruit trees. Entomological investigations made so far indicate that these sprays in concentrations of from one to two per cent are as good as, or better than, lime-sulphur, as a control for scale. The new emulsions are much cheaper than lime-sulphur, and are less disagreeable to work with. If more extended experiments verify the indications that engine oil is an efficient insecticide, there is only one objection to the adoption of this spray as the standard dormant treatment for scale on deciduous fruits. That is the effect of the oil on the tree. It is for the horticulturist to decide whether or not applications of oil affect the physiological processes of the plant in sufficient degree to cause appreciable harm. Of course, the final decision of this question will be based on careful plot experiments covering a period of years. Such an experiment

was started in the spring of 1923 at the Missouri Agricultural Experiment Station.

That a film of oil on the surface of a plant organ may affect the physiological processes of that organ is certain, as a study of available literature will show. The effects may be due to the penetration of the oil, or a fraction of it, into the cells; to a limitation of gaseous exchange between the tissue and the outside air; or to a combination of these two phenomena. Theoretically, any fat-soluble substance should penetrate the cuticle, the cell walls and the protoplasm of plant tissue. Some substances, like ether and chloroform, either penetrate more rapidly than heavy mineral oils, or else have a much more profound effect in equivalent amounts.

Investigators have usually considered that oil injury was due, in part at least, to penetration of fractions of the oil into the cells. This belief was strengthened by the work of Shafer (15) who found that insects were killed by exposure to the fumes from liquid oil, and also that it was almost impossible to kill them by smothering. Vickery (17) quotes Gray that unsaturated petroleum products are more injurious to plants than the saturated series. This is important in that kerosene, crude oils, and distillates which have been used in home-made emulsions and in proprietary miscible oils, may contain a considerable quantity of unsaturated hydrocarbons, while the residual oils used in the engine oil emulsions probably contain a very small amount of unsaturated compounds.

There is in the literature some evidence which may be construed to show indirectly that the gaseous exchange between the tissues of the plant and the air, is affected by the oil film on the surface. The opening of the blossom buds is sometimes retarded by applications of oils. Regan (14) has reported this phenomenon in the Northwest following the use of certain miscible oils. Pickering found that the application of oils to dormant apple twigs sometimes caused a marked retardation in opening of the buds. Such retardation might be assumed to result from an accumulation of carbon dioxide inside the buds, or to a deficiency of oxygen. Essig (7, 8) reports on the other hand that dormant applications of oil sprays hasten the blooming of deciduous trees in California from 1 to 3 weeks. At the Missouri Station, in the spring of 1923, the blooming of Montmorency cherries was hastened 3 to 6 days by the application of 20 per cent Diamond Paraffin oil. Essig (8) suggests that the increase in temperature caused by the dark color resulting from the oil spray, is the cause of this hastening of blooming.

It has been reported by Childs (5) that when oils are applied to apple foliage the leaves, while not burned or killed, remained oily for several weeks and failed to increase in size. Yothers (18) sprayed citrus trees 3 times in succession with a one and one-half per cent emulsion of 24° Baume Paraffin oil, and noted that the leaves were stunted, and that the fruit was both late in maturing, and small and sour as well. Single applications caused the old leaves to fall, and in the case of young leaves seemed to prevent the normal increase in green colors seen in the checks. Excessive

applications caused both old and young leaves to fall. Magness (11) has noticed that under certain conditions leaves previously sprayed with oil contain no starch. While there is no direct evidence, it still seems probable that the film of oil left by the spray may reduce transpiration, and hence, may tend to cause abscission. It is even more probable that the oil film may affect the assimilatory processes of the leaf, by limiting the entrance of carbon dioxide.

Magness and Burroughs (12) offer direct evidence that an oil film on the surface of apple fruits affects gaseous exchange. Apples were dipped in crystal-oronite, or petrolatum oil, which is a neutral non-drying residual oil with properties not differing greatly from the oils used in spraying, and were afterwards allowed to drain. Apples so treated softened more slowly than the checks, and developed the flavor characteristic of fruit held under anaerobic conditions. The evolution of carbon dioxide from Winesap apples held at 65°F., was reduced only 12 per cent by such a coating of oil, but analyses of the air in the intercellular spaces showed a composition of 2.6 per cent oxygen and 25.3 per cent carbon dioxide; while check apples had 5.7 per cent oxygen and 18.3 per cent carbon dioxide. The fruit softened very little in 4 weeks. The opinion was expressed at this time that lack of oxygen was the cause of the retardation of the softening process. Burroughs (3) measured the carbon dioxide evolution from Wealthy, Baldwin and Wagener apples at 68.5°F. after dipping them in crystal-oronite. In the case of apples which were eating ripe, the rate was reduced sometimes as much as one-half. In the case of immaturely picked apples which had not softened much, the rate of carbon dioxide evolution was actually increased by the treatment. Observations on softening, flavor, and aroma of the apples, indicated that at the temperature prevailing the application of an oil film induced partly anaerobic conditions inside the fruit. The carbon dioxide given off may have been the product of incomplete oxidation of respirable material in the fruit. Under conditions such as these, much more carbon dioxide would be given off in proportion to the energy released, than would be the case in normal aerobic respiration.

In the above experiments, the apples were dipped in pure oil and merely allowed to drain. In the case of oil sprays, and this it is with which we are dealing, there is a thinner film over the plant than that which would result from the treatment previously described. Magness describes respiration experiments on apples covered with a very thin film of oil as follows (11): "We used oil of full strength (American Mineral Oil) and applied a very thin coating by wiping the fruit with a cloth which was slightly moistened with oil. This gave a sufficient amount of oil to make the surface of the fruit appear slightly oily, although the total amount present was very slight. We found that fruit so treated softened somewhat less rapidly than fruit not so treated. Respiration tests showed that the rate of carbon dioxide output in such fruit was reduced by approximately 25 per cent by this treatment, both at temperatures of 32°F. and 68°F. This, we believe, was due not to the inhibition of the entrance of oxygen into the tissues, but

rather to a direct effect of the larger accumulations of carbon dioxide within the tissues which resulted from the oiling treatment. The fact was definitely developed at least that even a light oil distinctly disturbed the physiological processes going on in apples.''

In the course of investigations at the Missouri Experiment Station concerning the effect of oil sprays on fruit trees, some preliminary experiments have been carried on to determine the effect of the oil film on physiological processes in plants. Qualitative tests for starch in apple leaves sprayed with 2 per cent oil showed that leaves which were partly burned by the spray generally had no starch in the portions which were still alive. The samples were taken in the afternoon and the checks contained an abundance of starch. Leaves that appeared to have their growth arrested because of the oil spray also contained no starch. On the other hand, many sprayed leaves gave as marked a reaction to the iodine test a few days after the application as did unsprayed leaves. The transpiration from one-year twigs of apple treated with 2 per cent oil was measured by the burette potometer method. Under field conditions, where there was killing of portions of the leaves, the transpiration rate of sprayed twigs was markedly lower than that of the checks. This was, of course, due in part to the death of the transpiring surface. Where twigs were sprayed but no killing of tissue resulted, the decrease in transpiration rate was so small as to be obscured by the experimental error. In these experiments the twigs were removed 2 or 3 days after the trees had been sprayed. It is impossible to say how thoroughly they were covered with the oil film. In one experiment 10 twigs were taken from an unsprayed tree, the transpiration determined for one day, and then half were dipped in 2 per cent emulsion and the subsequent transpiration determined. These twigs were held in the laboratory where the air was stirred by an electric fan. A very marked reduction in transpiration rate resulted from the dipping of the leaves in the oil emulsion.

In addition to the experiments mentioned, observations on the visible effects of oil applications at the Missouri Station indirectly prove that physiological processes may be affected by the oil. Leaves were often retarded in growth, or made to turn yellow by oil sprays. Abscission of leaves, or fruit, sometimes resulted from such applications. Death of portions of leaves was a common result of summer applications, and in a few cases death of fruit buds, or of entire limbs, followed the application of oil in high concentrations during dormancy.

Our information at the present time on the effect of an oil covering on plant organs may be summarized as follows: From theoretical considerations, and from observations and experiments, it is quite certain that a covering of oil on the surface of a plant organ may affect the physiological processes of that organ. It is probable that under some conditions the effect of the oil may be infinitesimal. Under the conditions prevailing in actual dormant spraying practice, it appears that ordinarily the effect of the oil film is slight, or at least no injury results from its presence. On

foliage the effect is more marked, injury is apparent in most cases, but may vary from slight to severe in degree.

The purpose of the foregoing discussion of possible physiological effects of oil sprays was to bring out points which will be of value in considering a practical problem which is before us at the present time: that is, the probable effect of continued applications of 2 per cent lubricating oil emulsion on deciduous fruit trees in the dormant stage. There has always been considerable objection to the use of oil sprays on the part of fruit growers and cases of injury from the use of oil always receive considerable publicity. The attention of the Department of Horticulture at the University of Missouri has been called to various rumors circulating among fruit growers that trees sprayed with oil emulsions are injured, or dying. We are informed that the same state of affairs exists in the Pacific Northwest. In several cases these statements have been either started or passed on by selfish interests. One case of injury investigated by the department was due to spraying with an emulsion which had been broken down by the action of hard water, so that the trees receiving the dregs were sprayed with pure oil. Since practically all the emulsions used in this country have had soap as the emulsifying agent, it is probable that many cases of oil injury are due to breaking of the emulsions in the presence of hard water, or water contaminated with lime, or lime-sulphur. If growers are instructed to use as a stabilizer a freshly made up ½-½-50 Bordeaux with all oil-soap emulsions, or if emulsifying agents other than soap come into general use, this danger may be avoided.

Although the possibility of cumulative injury from the use of the new emulsions has been pointed out (4), so far as the writer is aware no statement of any injury from dormant applications of these sprays has appeared in the literature. Injury from kerosene and crude oil emulsions and from proprietary emulsions have been mentioned by Regan (14), Melander (13), Felt (9), Pickering (2) and others. The report of a recent conference between representatives of the Federal Bureau of Entomology, the Illinois National History Survey and the Indiana Experiment Station, contains no mention of injury from two years' application of engine oil emulsion; while the statement is made that two or three per cent engine oil may be applied safely to dormant peach trees. The results of one year's work at the Missouri Station on the effect of oil sprays of various kinds and concentrations on dormant trees, show no visible injury from applications of oil in concentrations up to 12 per cent on any kind of trees, and no injury on apples in concentrations up to 50 per cent of oil. Over 50 applications of oil sprays of various kinds and concentrations, were made in March and April, 1923, on both apples and stone fruits. No delay in the opening of fruit buds was detected, although the opening of Montmorency cherry was hastened in one case.

Although the experience so far of investigators and growers indicates that no injury will result from one or two years' applications of two per cent engine oil, there is still the possibility of damage following several successive applications. In the early history of kerosene emulsions, single applications of spray were

pronounced non-injurious by horticulturists, yet the yearly use of the oil resulted in cumulative injury. In the absence of information on this point for the engine oils, we can draw valuable conclusions from the experiences of fruit growers with oil sprays other than kerosene emulsion. It is well known that many orchards in the Middle West and in the East have been sprayed for years with proprietary miscible oils without noticeable injury. Certain cases of injury have been reported, particularly in peach orchards, but they do not represent the general experience. From the available literature, it is learned that proprietary emulsions and home-made emulsions of crude oil or distillate have been safely used for years in California and in the Pacific Northwest. Personal correspondence with horticulturists and entomologists in that section gives further evidence that long continued use of oils in the dormant season is in general a safe practice. Now the crude oils and distillates used as the basis of both home-made and proprietary emulsions usually contain at least fractions which do not differ greatly from our engine oil emulsions in the properties of density and viscosity. In fact, the oils in some of the proprietary emulsions are almost the same as the paraffin oils recommended by Ackerman (1). When we consider that the concentration of oil applied in the Northwest when these sprays are used in the recommended strength, is from three to 10 times as great as is being used in the Middle West, it would appear that little or no injury is to be expected from the application of two per cent engine oil emulsion. Even a crude oil applied in a concentration of, say, 12 per cent would no doubt contain more than two per cent of hydrocarbons similar in properties to those in one of the paraffin oils used here. The crude oil might contain in addition to the equivalent of the residual oil, a considerable amount of unsaturated compounds, perhaps some acid, and certainly a large amount of lighter hydrocarbons which would perhaps penetrate the tissues more readily than the residual oil. On the whole, if high concentrations of crude oils, or comparatively unpurified distillates, can be used safely over a period of years on dormant trees, it seems improbable that any cumulative injury will result from the yearly applications of two per cent engine oil.

From the foregoing discussion, it seems that it would be safe to recommend two per cent lubricating oil emulsion as a dormant spray, provided that adequate precautions are taken to prevent the breaking down of the emulsion in the tank, and the consequent application of pure oil when the dregs of the tank are sprayed out. There is always the possibility that unexpected injury may develop in certain localities due to exceptional meteorological conditions, or to the internal conditions of the plant. With this in view, recommendations should be made with certain reservations. For instance, Melander (13) and others (14, 9) report injury following applications of oils just before severely cold weather. Until this kind of injury has been investigated under our conditions, we should not recommend applications of oil sprays during severely cold weather. There are plenty of warm periods in both winter and spring when the spraying can be done with more certainty that no injury will follow.

The possibility of using the new engine oil emulsions on foliage has received considerable attention since Ackerman showed their value in controlling scale. Where scale is severe, summer applications may reduce the number of fruits which are rendered valueless by its attacks. In the more southern regions, where scab is not severe, it is possible that the first spray application in the apple orchard might be delayed until the pink stage, when oil, Bordeaux, and arsenate of lead would kill scale, aphids, and chewing insects, and give protection against fungous diseases. Such a program would save the grower the cost of one application. Burroughs and Grube (4) give data which show that under some conditions at least, two per cent oil is effective against aphis. A scalecide which could be safely applied to foliage would also be of great value in the greenhouse.

The report of the conference on oil sprays, mentioned above, states that "dormant spraying is the only recommended control for the San Jose Scale." There have appeared in the literature, however, certain statements that indicate that two per cent engine oil emulsion may be safely used on apple foliage. Ackerman (1) reports that three per cent oil applied on a hot day caused burning, and that two per cent caused slight burning in some cases when used with other sprays. He states that "no case of injury has been observed on fruit sprayed with a two per cent emulsion during the summer. Some growers used a two per cent emulsion in several summer sprays without any injury." Davis (6) writes "Where the San Jose Scale has not been completely checked by the dormant sprays, it is desirable to spray with the lubricating oil spray when the young scale are developing, usually about the latter half of June. A two per cent emulsion, prepared as described above, will kill the immature scale and not injure the foliage." Cruickshank, in a circular letter of the American Pomological Society dated June 19, 1923, makes the following statement: "The lubricating or Red Engine Oil emulsion which has been used so satisfactorily as a dormant spray for the control of scale is now being used as a summer application against the same insect. The emulsion is combined with Bordeaux mixture, making an insecticide and fungicide. Including the Ozark section of Arkansas, where the applications were first made, under supervision of government experts, several states have had some experience with this material as a summer application. Here in Ohio on trees where scale was not properly controlled while the trees were dormant, this Bordeaux-oil emulsion combination was applied when the apples were about the size of hickory nuts. There was no damage whatever to fruit or foliage and the trees were undoubtedly saved from death by scale infestation. The same strength is used in the summer as in the dormant season, namely, a two per cent emulsion. The point is yet to be established whether constant use of this spray will develop injury or not. However, it has been used for several years without any indication of damage so far."

A considerable number of Missouri orchards were sprayed with two per cent engine oil during the summer of 1923. Observations in these orchards, and experimental spraying carried on at the

Experiment Station showed that under Missouri conditions, fc burning followed to a greater or less extent the application o per cent oil sprays. In some cases the burning was not noti until some time after the application. Burning which was no sidered serious by the fruit growers often involved a conside part of the leaf surface. The results of summer applicatio of oil at Columbia are presented in tabular form in Table I.

Data on effects of oil in the foliage of stone fruits are not included in the above table, but it may be stated that severe burning was the consequence of such applications. The experimental spraying with oil was all done with the idea that thorough wetting of twigs was necessary in controlling scale. For this reason a greater volume of spray was applied than is usual in summer spraying. This may have increased the toxic effect of the oil applications. Just why burning of apple foliage occurred at one time or place in these experiments and not at another, is not apparent. The main point is that the burning did often occur, especially with repeated applications. Foliage-burning and abscission of leaves and fruit are phenomena easily detected, however, and there is little danger that fruit growers will continue any practice which gives such apparent injuries. The possibility that the photosynthetic activities of leaves may be affected by the oil film without any obviously immediate effects, warrants more consideration. Previous mention has been made of the fact that oil-sprayed citrus and apple leaves often failed to increase in size, and some even turned yellow and dropped. On apple trees at Columbia where only one application was made, the growth of new leaves quickly obscured these effects, especially at the cluster bud stage when growth was rapid. The oil sprayed leaves could be distinguished from those which grew after the application by their leathery texture, oily appearance, and darker color. Where three successive applications were made, most of the leaves were of this type and new leaves grew out only very slowly. It is true that on the check trees many of the first formed leaves did not grow much, and some dropped of , so that the effect of one application, especially at an early date, may not appreciably affect the magnitude of the leaf surface.

It appears from the observations of Yothers (18) quoted above, and from observations at Missouri that three successive applications do decrease leaf surface to a considerable extent, therefore, it follows that one application must decrease it to some extent. Su a reduction would decrease the amount of carbohydrate forme just as reduction in leaf surface from any cause would. Howeve the retardation in leaf growth is probably due to the effect of th oil film in limiting the carbon dioxide supply. If this is the case assimilation by such leaves as did develop would be limited. Thi may or may not result in reduction of yield, depending on the pr vailing condition. Gardner, Bradford and Hooker (10) state the fruit bud formation may depend on an accumulation of carboh drates. It is conceivable that an inhibition of the assimilatory ac tivities of the leaves, due to an oil application previous to fruit bu differentiation, might make carbohydrate a limiting factor, thus decreasing the number of fruit buds formed. Sprays put on befor

[*Place these four pages in Proceedings of the American Society for Horticultural Science, 1923 page 276, article by A. M. Burroughs, entitled "Effects of Oil Sprays on Fruit Trees"*]

TABLE I

Results of Summer Applications of Oil Sprays to Apples, Columbia, Missouri, 1923

SINGLE APPLICATIONS

Date	Stage	Description of Trees	Spray Applied	Visible Effects On Trees
April 17	Early pink	1 Imperial Rambo 1 Nero 11 years old	[illegible] per cent oil soap	Some leaf burning but no apparent effects were noticeable 2 weeks after application
April 24	Pink	1 Ralls 1 Jonathan 25 years old	[illegible] per cent oil Bordeaux	Rather severe burning followed by leaf abscission on the Jonathan, leaves dwarfed, no effect on the Ralls, no effect on fruit buds
April 26	Pink	6 Grimes 4 Delicious in thick planting 5 years old	[illegible] per cent oil Bordeaux	No effect
April 26	Pink	4 Loveland 10 years old	1 per cent Crystal oronite Bordeaux	Slight foliage burning, no effect on fruit buds
April 26	Pink	2 Grimes 10 years old	1 per cent oil soap	Slight foliage burning, no effect on fruit buds
April 26	Pink	1 Grimes 10 years old	1 per cent oil Bordeaux	Slight foliage burning no effect on fruit buds
April 28	Late pink	2 Grimes 2 Delicious thick planting 5 years old	[illegible] per cent oil soap	No effect
April 28	Blooming	1 row in commercial orchard 6 trees 10 years old	[illegible] per cent oil soap	Little foliage burning, open blossoms killed no effect on buds
April 30	Blooming	2 Delicious 1 Grimes thick planting 5 year old	2 per cent oil Kayso	No effect except to kill open blossoms
April 30	Blooming	1 row in seedling orchard 14 trees 10 years old	2 per cent oil Kayso	Slight burning and dwarfing of leaves open blossoms killed
May 1	Blooming	1 row in commercial orchard 10 years old	2 per cent oil Bordeaux	A little foliage burning
May 1	Blooming	1 Delicious 1 Grimes 1 Jonathan thick planting 5 years old	2 per cent oil Bordeaux	No effect except killing of open blossoms

TABLE I—*Continued*

Results of Summer Applications of Oil Sprays to Apples, Columbia, Missouri, 1923

SINGLE APPLICATIONS

Date	*Stage*	*Description of Trees*	*Spray Applied*	*Visible Effects On Trees*
May 16	Late calyx	2 Grimes, thick planting, 5 years old	2 per cent oil-Kayso	No effect
May 16	1st summer	5 old Jonathan	1 per cent oil-soap with Bordeaux	Severe foilage burning; spray injury on fruit
June 5	Apples ¼-½ inch in diameter	1 Delicious in thick planting, 5 years old	2 per cent oil-soap with Bordeaux	No effect
June 30	Apples ½-¾ inch in diameter	6 trees in commercial orchard, 10 years old	2 per cent oil-Kayso with Bordeaux	Medium bad burning
July 2	Apples ½-¾ inch in diameter	5 trees in commercial orchard, 10 years old	2 per cent oil-soap with Bordeaux	Medium bad burning
July 2	Apples ½-¾ inch in diameter	2 Delicious in thick planting, 5 years old	2 per cent oil-soap with Bordeaux	Almost no effect
July 19	Apples ½-¾ inch in diameter	1 Delicious in thick planting. 5 years old	2 per cent oil-soap with Bordeaux	No effect
July 19	Apples ½-¾ inch in diameter	5 trees in commercial orchard, 10 years old	2 per cent oil-soap with Bordeaux	Medium burning
July 19	Apples ½-¾ inch in diameter	3 trees in commercial orchard, 10 years old	2 per cent oil-soap with Bordeaux	Medium burning

TABLE I—*Continued*

Results of Summer Applications of Oil Sprays to Apples, Columbia, Missouri, 1923

SUCCESSIVE APPLICATIONS

Date	*Stage*	*Description of Trees*	*Spray Applied*	*Visible Effects On Trees*
April 28 May 16 June 5	Pink Calyx 2nd summer	18 trees in seedling orchard, 10 years old	2 per cent oil-soap with Bordeaux 2 per cent oil-Kayso with Bordeaux 2 per cent oil-Kayso with Bordeaux	Effect at first only slight burning. Later severe burning of leaves and spotting of fruit, abscission of leaves and fruit and dwarfing of leaves resulted.
April 30 May 16	Pink Calyx	5 trees in commercial orchard, 10 years old. Jonathan, King David, Ben Davis, and Delicious.	2 per cent oil-Kayso with Bordeaux 2 per cent oil-Kayso with Bordeaux	Medium to severe burning on leaves and fruit. Crop reduced, leaves dwarfed
April 30 May 16	Pink Calyx	6 trees in frost orchard, 10 years old: Winesap, Ben Davis, Grimes, Jonathan, Rome and Benoni	2 per cent oil-Kayso with Bordeaux 2 per cent oil-Kayso with Bordeaux	Medium to severe burning on leaves and fruit. Crop reduced, leaves dwarfed
May 10 May 21 June 5	Calyx 1st summer 2nd summer	15 old weak Ben Davis	2 per cent oil-Kayso with Bordeaux, each date	Leaves burned and dwarfed, crop practically all dropped while checks did not
May 10 May 21 June 5	Calyx 1st summer 2nd summer	15 old weak Ben Davis	1 per cent oil-Kayso with Bordeaux, each date	Leaves somewhat burned and dwarfed; fruit did not all drop. All spray burned. Injury marked but less severe than where 2 per cent oil was used

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blooming time when the leaf surface is relatively small might not have as great an effect as those applied after blooming, but it is reasonable to expect that under some conditions even a small reduction in carbohydrate manufacture might reduce the number of fruit buds formed. In this regard, it is of interest to note that Talbert (16) found no marked reduction in yield over a three year period when orchards were sprayed in the pink stage with concentrated lime-sulphur. There was considerable burning of the young leaves, but apparently fruit bud formation was not affected to an appreciable extent. However, until this question is settled by experiment, it is believed that the use of oil sprays on apple foliage after the delayed dormant period and before fruit bud differentiation, should be considered a practice which might reduce yield.

Summarizing the information on summer spraying with oil, it has been found that, under Missouri conditions, foliage burning is often a consequence of oil applications. Severe abscission of leaves and fruit follows successive applications during the summer. Severe burning always occurred when oil was used on the foliage of stone fruits. At Columbia, applications of oil in the pink stage caused only a little burning. In some cases, oil applied later in the summer resulted in little or no burning. Various growers in Missouri, and experimenters in Arkansas, Indiana, and Ohio, have reported that no burning followed the use of two per cent oil in summer. There is a strong possibility that even where no burning occurs, assimilation by the leaf surface is reduced to some extent when the leaves are coated with an oil film such as would be left after spraying with oil emulsion. No direct evidence has been offered to show that such a film affects the well-being of the tree or the size of the crop. In fact, no direct quantitative proof has been offered that assimilation is affected under field conditions where no burning occurs. However, from theoretical considerations, and from certain indirect evidence, we must admit that such a state of affairs is likely to exist. This being the case, it is believed that as a commercial practice, summer applications of oil on the foliage of deciduous fruit trees should be discouraged until its safety is demonstrated by experiment.

NOTE—The list of literature cited in the above paper was not submitted for publication. Secretary.

Some Physiological Effects of Bordeaux

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It is probably a safe estimate to say that 95 per cent of the work done with spraying materials has had to do with the fungicidal, insecticidal and chemical properties of the material. Comparatively little is known of the effects of the spraying materials upon the functions of the plant.

It is the purpose of this paper to discuss certain physiological

effects of Bordeaux. Two distinct effects have been observed; first, the reduction in the size of cherries, and second, some apparent influences on the frost resistance of apple and cherry leaves. The results to be given are offered simply as a progress report.

In 1921, in connection with experiments in the Grand Traverse district for the control of cherry leaf-spot, it was observed that the fruit on trees sprayed with Bordeaux was smaller than on trees treated with lime-sulphur, sulphur dust, or copper sulphate dust. The reduction in the size of Montmorency cherries was quite noticeable, and on English Morello the Bordeaux sprayed fruit was so much smaller that the pickers objected to picking it. A report of the observations has been published (2).

In 1922, the experiment was repeated and definite records were obtained to determine how much Bordeaux might reduce the size of the fruit. Records could not be obtained for check trees as they were defoliated by leaf-spot before harvest. The largest cherries were borne on dusted trees, so in the absence of a check, the dusted cherries were considered as 100 in size. The comparative weights of cherries from the various plots were as follows:

Comparative Size of Cherries, 1922

	Montmorency	English Morello
Dusted	100	100
Lime-sulphur	90	83
Bordeaux	87	65

Definite records were again obtained in 1923 from Montmorency trees. It was possible this year to get records for the check trees as no defoliation from leaf-spot occurred before harvest. The comparative sizes of the fruit from the different plots are shown in the following tabulation:

Comparative Size of Cherries, 1923

	Montmorency
Check	100
Dusted	95
Lime-sulphur	85
Bordeaux	63

Similar effects were observed in another orchard at East Lansing, and in this experiment the use of a hydrated lime spray, also caused a reduction in the size of the cherries. It should be stated here that the Bordeaux used in all the experiments mentioned was made with an excess of lime, or in other words, it was an alkaline Bordeaux.

A reduction in the size of sweet cherries by Bordeaux has been reported by Fisher (4) as occurring in the Northwest. Fisher reported a difference in varieties in this respect and a glance at the figures for 1922 shows that the reduction in the size of English Morello was much greater than with Montmorency. English

Morello ripens much later than Montmorency and it was found that the variety which Fisher reported as being susceptible to the effect of Bordeaux is also one which ripens late.

The question, "in what way is this reduction in size by Bordeaux brought about" naturally presents itself, but is not so easily answered. A survey of the literature brings to light some interesting work concerning the effect of Bordeaux on certain activities of plants. All workers have not agreed in their conclusions, but it has been found, in several instances, that Bordeaux increases transpiration. Frank and Kruger (5) worked with potatoes and report increased transpiration by Bordeaux sprayed plants. Duggar and Cooley (1) found that Bordeaux increased transpiration in castor bean leaves and potted tomato plants. Others report similar results with other plants.

During the summer of 1923, transpiration studies with English Morello cherry were made. Shoots were cut from trees sprayed with Bordeaux and lime-sulphur, and from unsprayed trees. They all bore leaves and cherries in approximately the same numbers. The shoots were set in water in graduated cylinders so that the water loss could be read directly. The water loss per unit area of leaf surface was calculated and with the loss from the unsprayed shoots as 100 the following values were determined.

Relative Water-loss by Cut Shoots

Check	100
Lime-sulphur	112
Bordeaux	125

Shoots were again cut and the rate of water loss per unit area of leaf surface during wilting was determined for a 24 hour period. These shoots bore both leaves and cherries and the cherries were still green. The comparative values were determined as before and were as follows:

Relative Water Loss in Wilting

Check	100
Lime-sulphur	111
Bordeaux	151

These figures again show that there was a greater loss from Bordeaux sprayed shoots. The question may naturally be asked "where did this water come from when none could be taken in?" A partial answer may be found in the fact that at the end of 24 hours the cherries attached to Bordeaux sprayed shoots were badly wilted while those on unsprayed shoots showed very little evidence of wilting. This would indicate that leaves sprayed with Bordeaux have a greater power to draw water from the green cherries, than do leaves which have not been sprayed.

Further evidence that the Bordeaux sprayed leaves extracted excessive amounts of water from the fruit, was obtained from another experiment. Shoots, similar to those used in the other

tests, were cut from the trees, the leaves cut off, the cherries coated with paraffin, and then set in water in graduated cylinders. The amount of water taken up by each cherry was calculated and the comparative values follow:

Water Absorbed by Cherries

Check	100
Lime-sulphur	250
Bordeaux	716

The cherries on Bordeaux sprayed shoots took up over seven times as much water as those on unsprayed shoots. This would seem to indicate a water deficit in the Bordeaux sprayed cherries due to the previous extraction from them by the leaves.

A comparison of the results with Montmorency in 1922 and 1923, shows that in 1923 the reduction in sizes on Bordeaux sprayed trees was much greater than in 1922. In this connection it may be stated that in 1922 the amount of rainfall during the fruit growing period was decidedly greater than during the same period in 1923.

The second effect of Bordeaux mentioned above, which consisted of an apparent decrease in the frost resistance of the leaves of apple and cherry trees, was observed in October, 1923. Several experiments had been under way during the summer in connection with some foliage injury studies. One experiment included five year old trees of Baldwin and Red Canada apples. The materials used were 4-4-50 Bordeaux, 3-5-50 Bordeaux, and lime-sulphur solution, 1-40. Three applications were made during the summer. Each tree was divided into sections so that one portion of the tree was left unsprayed and served as a check against the sprayed portions of the tree. Another experiment was with five year old Rhode Island Greening trees and each tree was divided so that one-half was sprayed and the other half was not. Bordeaux, 4-4-50 was the only material used, and one application only was made. It was put on in August. The experiment with cherries was with 14 year old Montmorency trees. Every tree was sprayed all over and there were no checks. The materials used were 4-4-50 Bordeaux and lime-sulphur, 1-40. These trees received three applications, all of which were made in the period between petal-fall and fruit harvest.

Observations were made on October 1 on all the trees and nothing unusual in the condition of the foliage was seen. Observations were next made on October 10 and at that time it was found that in every instance where Bordeaux had been used the leaves were brown, dry and dead, but still remaining on the tree. This was uniformly true for all the varieties of apples and for the cherries regardless of how many applications had been made or where they were made. All check limbs and all limbs on trees which had been sprayed with lime-sulphur were in normal condition.

There had been a series of five killing frosts on consecutive

nights, beginning with October 5. The minimum temperatures for these nights were 32, 30, 31, 31 and 32. It was found on further observation that the apple and cherry leaves were in a condition very similar to that of nearby grape leaves which had been killed by frost. After considering various factors which might have been responsible for the condition of the Bordeaux sprayed leaves, the conclusion was reached that the Bordeaux must have reduced their resistance to frost injury so that they were killed, while the leaves on check limbs and on limbs, or trees, sprayed with lime-sulphur, were more hardy, and were not affected by the prevailing temperatures.

The factors which were directly responsible have not been determined, but the condition certainly was due to some effect of the Bordeaux. Was the composition of the cell sap affected in such a way that its concentration was lowered with a consequent raising of the freezing point? The work of Ewert (3) with currants indicates that Bordeaux may have some effect on the amount of sugar found in the leaves. Was the formation of water soluble pentosans inhibited, or prevented, so that the water holding capacity of the leaves was reduced? If this were true, the leaves would be more susceptible to frost injury as shown by the work of Rosa (6). Was the radiation of heat from the leaves accelerated by the film of Bordeaux which covered them so that they were cooled to a lower point than leaves which were unsprayed, or were sprayed with lime-sulphur? The effect of Bordeaux in this respect has not been determined, but it is well known that different materials have different radiation values.

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Color Control in Forcing Hydrangeas*

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ONE of the important flowering plants used for forcing for Easter and later, is the hydrangea. But this chameleon like plant has been at once the despair of florists and a subject of interest to plant physiologists since first introduced into Occidental culture, about the latter part of the 18th century. A plant bore pink flowers at one time, blue at another, or perhaps part pink, part blue, or an intermediate mauve, or lilac. Gardeners had come to believe that iron in some form was responsible for making the flowers blue, as is shown by Schubler, (1) Jager, (2) and others. Donald, (3) however, believed that alum could be of equal force. Various natural soils were found which had the effect of producing blue flowers. All of these soils gave evidence of a high iron content, so that the iron oxide was held responsible for the change. Molisch (4) did the most extensive work with this plant, approaching the problem as a physiologist with a practical training in horticulture. He found that certain natural soils, peaty soils and "new" land. i. e., soils recently cleared of forest, were effective in producing the blue color. Positive results in the production of blue flowers were secured by the use of alum, aluminum sulfate, and ferrous sulfate, while negative results were secured with iron filings, charcoal, potassium sulfate, sulfates of copper, manganese, nickel, cobalt, and ammonium, and carbonate of potassium. Molisch concludes that the blue color is brought about by the contact of iron and aluminum, in inorganic salts, with the red anthocyan of the flower, accounting for the red color in ordinary soils which are high in iron and aluminum by the assumption that these two elements are quickly changed to organic forms in the plant tissue. It is only by the use of such excessive amounts that a part at least reaches the anthocyan in an inorganic form, resulting in a color change.

THE PROBLEM

The difficulty in growing this plant in large numbers is to have them come true to color. A previous paper (5) by the writer reported that in a practical way, pink color could be obtained by the use of lime, but that the use of excessive amounts of slaked or hydrated lime would bring about injury to the plant by chlorosis. It was found that excessive amounts of ground limestone were not injurious. What, then, contributes to this color change and how can it be controlled in a practical way?

THE EFFECT OF NATURAL SOILS

To check up the results of Molisch, various natural soils were collected, and plants were grown in these. These soils varied in hydrogen-ion concentration. A sandy soil with a pH of 5.7 pro-

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duced blue flowers; a loam testing pH. 6.1 gave blue flowers; a loam testing pH. 6.2 gave magenta flowers; a heavy clay loam testing pH. 6.1 gave magenta flowers; a gravelly loam testing pH. 6.6 gave pink flowers. The latter soil grew good alfalfa. Later a heavy leafmold soil with a pH. of 5.2 produced blue flowers, and a greenhouse compost of a clay loam mixed with sand with a pH. 6.7 gave pink flowers. The variety used was Otaksa. The method of Gillespie (6) was used in hydrogen-ion determinations.

A nursery was visited where hundreds of plants were seen in bloom, all growing in soil of the same origin and presumably of the same general composition. As all ranges of color were seen, soil samples were taken from individual pots of plants, within a variety, showing ranges in color. It was possible in nearly every case to get the extremes, pink and blue, and an intermediate mauve, or lilac.

Upon making hydrogen-ion determinations, it was found that there appeared to be more or less a definite relationship between the hydrogen-ion concentration of the soil sample and the flower color. In general, where the hydrogen-ion concentration was 6.4 or lower, a pink color resulted. pH. 6.2 seemed to be the critical point, as practically all soils showing this value produced intermediate colors. At pH. 6.0, or higher, blue color was produced. There is evidence of a slight variation due to variety.

Outline of an Experiment

A soil was selected which had a high hydrogen-ion concentration—5.2. This soil was not ideal for plant growth, being rather heavy, but it was full of organic matter. It later developed that the soil lacked available minerals. To this soil, in one series, were added various amounts of ground limestone, the amounts being 2000 pounds, 4000 pounds, 10,000 pounds, 20,000 pounds, and 40,000 pounds to the acre, 6 inches deep being taken as the unit. Sufficient plants were grown in each treatment so that when the need arose for repotting, the soil to be added could be radically changed. Of the control plants, one-half were repotted with untreated soil and one-half with soil containing 40,000 pounds to the acre of ground limestone. Of those receiving an initial application of 2000 pounds to the acre, three were repotted with crude soil, three with soil containing 2000 pounds of ground limestone, three with soil containing 10,000 pounds of ground limestone, and three with soil containing 40,000 pounds of ground limestone. So through the series, each group being treated approximately the same: part of the plants being continued with the same treatment and part having no lime, less lime, and more lime added, at subsequent repotting.

In another series, 20,000 pounds to the acre of ground limestone was taken as the unit of application, the variable treatments being in the amount of manure added, each manure series being run with and without lime. The manure was thoroughly rotted, partly dried and passed through an eight mesh sieve so that as near a homogeneous mixture as possible could be obtained. In the subsequent repotting, part of each original treatment was repotted with

soil containing the same variable substances as in the initial treatment and part without one of them.

The plants as received were out of two inch pots. All soil was carefully washed from the roots and they were potted in four inch pots on July 5, 1922. On November 2 the hydrogen-ion concentrations were determined, the plants soon after being dried off and stored. They were brought out of storage at various dates, being timed to bloom about Easter, Memorial Day, and for the Annual Field Day on June 15. On March 21 and 22, the plants were shifted to six inch pots, at which time the treatment was changed on a part of each group as noted above, the balls being placed intact with the additional soil of the different composition.

The Influence of Lime on the Hydrogen-ion Concentration of the Soil

Hydrogen-ion concentrations were determined after the plants had been growing about four months. In the case of each mix, the residue had been preserved and kept under approximately the same cultural conditions as the growing plants. While the colorimetric method of determining the hydrogen-ion concentration of soils is not always satisfactory, due to the turbidity of the samples, the determinations are near enough correct for the purposes of this paper.

Table I

Mean Hydrogen-ion Concentrations of a Soil Treated With Various Amounts of Ground Limestone at the End of Four Months

Treatment	Calcite Limestone Planted	Calcite Limestone Residue	Dolomite Limestone Planted	Dolomite Limestone Residue
Control	5.9	5.3	5.9	5.3
2000 pounds limestone	6.2	6.3	6.2	6.1
4000 pounds limestone	6.4	6.5	6.3	6.5
10,000 pounds limestone	6.8	6.9	6.5	6.8
20,000 pounds limestone	6.8	7.0	6.6	6.9
40,000 pounds limestone	7.0	7.0	6.7	7.0

Initial pH. 5.2

It will be noted that the calcite limestone seems to decrease the hydrogen-ion concentration at a rate slightly more rapid than in the case of dolomitic limestone. The need of excessive amounts to depress the pH as the neutral point is approached, is also apparent.

Correlated Flower Colors

The variety Souvenir de Mme. E. Chautard was used in the above series. This variety blooms on every break. All of the control plants and those receiving 2000 pounds to the acre throughout the test were blue. Those plants which received 4000 pounds throughout the test were of intermediate colors—mauves, lilacs, etc.,—with a tendency more toward the pink side. All the other treatments produced pink flowers.

Effect of Changing the Lime Treatment in the Subsequent Repotting

As noted above, when the plants were shifted to six inch pots, part of each group received, in the additional soil, different amounts of lime. It was obviously impossible to determine the pH of these lots because the center ball was of the old soil, with the ring between this ball and the pot of different composition.

The effect upon the plants was, however, apparent, especially where the variations were extreme. The impoverished condition of the soil mitigated, to some extent, against the fullest realization of our predictions, but the results were positive enough. On those plants which started with 10,000, 20,000 or 40,000 pounds of limestone, where they produced terminal flowers, pink flowers were formed. In the cases where the plants so treated originally were repotted with raw soil, those cymes that were produced on lateral shoots were blue mauve and blue. Those plants which were in the control, or treated with 2000 or 4000 pounds of ground limestone, but which in the subsequent repotting received soil containing 20,000 or 40,000 pounds of ground limestone, produced all blue or mauve terminal cymes, but produced mauve, or pink cymes, from lateral buds.

An examination of the root balls showed the reason that more decided results were not obtained. As was stated above, the soil was impoverished and it was not desirable to feed the plants with the usual dressing—manure water—due to the probable effect of the manure water upon the soil reaction. So in many cases the roots had not reached, or had barely reached, the outer surface of the soil. Had growth been more vigorous, most decided results would probably have been obtained.

Effect of Manure, With and Without Lime, on the Hydrogen-ion Concentration of the Soil

The generally accepted conception of the reaction of manure is that it is acid. The manure used in this experiment gave a different result. A 24 hour infusion tested decidedly alkaline (pH. 7.6). It was, however, very well rotted, practically no fiber remaining. The influence of this manure in assisting in adjusting the reaction of the soil was as follows, determinations having been made about four months after potting the plant: residue, pH. 5.3; control, pH. 5.6; 10 per cent manure, pH. 5.8; 20 per cent manure, pH. 6.0; 40 per cent manure, pH. 6.3. The latter is equivalent to the effect of 4000 pounds to the acre of ground limestone and the two preceding the last, 2000 and 2500 pounds to the acre.

Apparently, the manure, especially in the 40 per cent application hastened the reduction of the limestone, as in the cases where manure was used, lower pH. values were obtained, in many cases being 7.5. This is evidenced also in the growth of the plant. Whereas, in the previously cited series amounts up to 40,000 pounds of ground limestone to the acre were used, no apparent injury to the plant was evidenced by chlorosis. In the series under discussion, however, two plants of the 20 per cent manure with 20,000 pounds of limestone, and four plants of the 40 per cent manure with

lime group, became slightly chlorotic before the end of the growing season, an indication of too much lime.

Effect Upon Flower Color

Those plants which flowered under the same continuous treatment gave approximately the same result as in the previous series, the variety Baby Bimbenet being used in this series. The control produced blue flowers, as did those with 10 per cent manure and 20 per cent manure. All treatments with lime (the unit being 20,000 pounds to the acre), produced pink flowers. The 40 per cent manure produced mauve, or intermediate colored flowers.

When the treatments were changed at the repotting, the results were positive, but were slow in appearing. The reason apparently is that the manure, part of which must have been in a colloidal condition, acted as a buffer and prevented the entrance of the lime into the plant as rapidly as in the former series. All the manured plants made a vigorous growth, root and top, and it was expected the color changes would be more rapid.

In one case, the plant was in a limed soil with 10 per cent manure from July 5, 1922, to March 11, 1923, and was then repotted with a soil containing 10 per cent manure, but no lime. A terminal bloom was decidedly pink. Then bloomed a lateral which was light mauve. Another lateral blooming later produced a flower head colored lavender-violet, according to Ridgway (7), or somewhat more toward the blue side, showing that gradually the acid soil was having its effect.

Hydrogen-ion Concentration of Plant Juice in Flowers

With crude methods of extraction (grinding in distilled water) and crude methods of determination (colorimetric method), hydrogen-ion concentrations were made of a few flowers. Several deep pink cymes gave pH. 5.0 to 5.2, blue gave pH. 4.3 to 4.5 and white pH. 4.4 to 4.6. Finer methods will probably show a direct relation between the pH. of the soil and the pH. of the plant juice, within the limits of any one variety.

Plants With Cymes of Two Colors

In the discussion of the second series above, attention was called to a plant which bore cymes of three different colors. It frequently happens, when hydrangeas are grown in the open, that cymes of different colors are produced at the same time on different parts of the plant.

An interesting exemplification of this is reported by Hoffman (8). A small pot was sunk inside of the larger one and a plant was selected that had two good roots and two shoots which "corresponded anatomically" with the roots. There was a weak third center shoot. The plant was set astride the smaller pot, one root being within the small pot containing a soil which would "blue," and the other root in the outside, or larger pot, in a good garden soil. In the course of time, the plant bloomed and the twig associated with the root in the small pot produced a blue flower, the other a pink flower. The center shoot produced a flower which was violet.

In our investigations we tried to duplicate this, but cultural methods were not quite ideal so that while one shoot bore a cyme that was pink, the other shoot bore a cyme that was blue mauve. This was due to trying to keep the plants growing all winter while, as a matter of fact, they require a rest period.

The probable explanation of parti-colored cymes in the open ground is the unhomogeneous mixture of the soil. One root may be in a location where the soil is capable of producing pink flowers, while another root may be in a location where the soil influences blue.

Discussion and Conclusions

It is evident that the soil reaction is of great influence in the control of color of the flowers of the hydrangea. Plants growing in soils with pH. 5.0, or higher, consistently produce blue flowers while those in a soil of pH. 6.6, or lower, produce pink. Between these may occur a number of intermediate colors. This soil reaction appears also to be directly associated with a corresponding difference in the reaction of plant juices extracted in a rough way from the flowers. The color can be controlled, then, by adjusting the soil reaction by the use of lime, and it has been found that 10,000 pounds of ground limestone to the acre six inches deep, in any garden soil, will influence the production of pink flowers. The use of ground limestone is recommended, as amounts up to 40,000 pounds have been used without serious injury, while a slight excess of slaked, or hydrated lime, will bring about a chlorotic condition resulting in injury to the plant.

At what stage of growth the color can be influenced has not been definitely settled, but, with such varieties as bloom from lateral shoots of the same season, color can be influenced in the blooming season by potting with a soil very strongly tending to influence toward the color desired.

Whether the color is influenced by reaction solely, or whether it is, as Molisch (4) believes, influenced by the presence of varying amounts of the elements iron, or aluminum, or the inorganic salts of these elements, is a question that can be settled only by growing the plants in cultures free from iron and aluminum. Efforts are being made to find a medium in which the plant will grow in a sand substratum and it is hoped that data on this point will be available in another year. It is known, however, that the reaction of the sap of various plants influences the reception of iron into the plant system. If, then, Molisch's view is the correct one, the soil reaction as influencing the reaction of the plant juice may be of equal importance with the presence of iron and aluminum.

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Influence of the Carbohydrate-Nitrate Content of Cuttings Upon the Production of Roots*

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THE following evidence has been secured which indicates important influences of carbohydrates and nitrates upon the rooting of cuttings.

Tomato and tradescantia** plants were grown in small flats and pots of river sand. They were planted about two inches apart and grown until one cutting could be secured from each plant. Nutrient solutions were applied every 10 to 14 days in the earlier series, and in the later series twice a week to hasten growth. Tap water was also added when necessary. A complete nutrient solution consisted of calcium sulphate, magnesium phosphate, and potassium nitrate each in .007 molecular concentration. In solutions without nitrates, potassium sulphate was substituted for potassium nitrate. Iron was supplied by small quantities of ferrous sulphate, or ferrous tartrate. Complete nutrient solutions were added to the sand until the plants were nearly large enough for cuttings. Then, during the period of carbohydrate reduction, to be described later, a change was made to nutrient solutions without nitrates. This change was made to insure a uniformly low nitrate content in all the cuttings.

Not over 24 hours before making the cuttings, complete nutrient solutions were given to those plants which were to be high in nitrates, and nitrate-free solutions were given to the others. In this way considerable differences were secured in the carbohydrate content, and in fact no differences could be detected between the high carbohydrate lots of any one series. It should be noted that this increase in nitrates was obtained in a perfectly normal manner, namely, by absorption through the roots.

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** Tradescantia virginiana, L.

Striking differences in the carbohydrate content of cuttings were obtained by darkening tomato plants 10 to 14 days, except for a couple of hours each day. Tradescantia was darkened 35 to 44 days. If the plants contained much starch, the daily exposure was omitted the last day, or even two days. No attempt was made to shut out all light, but enough was excluded to secure the required differences without causing any apparent injury. Artificial light was sometimes used on plants, which were not darkened, to increase their carbohydrate content.

Cuttings were classified as high or low in carbohydrates according to the relative amounts of starch and free reducing substances as determined by microchemical tests. No doubt other carbohydrates were present, but it is hardly probable that the content of these would necessitate a different grouping of the cuttings than was made. For the tests of starch the iodine-potassiumiodide was used. Benedict's solution was used for free reducing substances. The cuttings, which were classified as low in carbohydrates, either did not show any starch and free reducing substances, or only traces, with the exception of a few which showed small amounts of reducing substances. These cuttings were instriking contrast to those high in carbohydrates, the cells of which, especially in the pith, were generally well filled with starch and free reducing substances.

The diphenlyamine-sulphuric acid test was used for nitrates. Sections from cuttings that were high in nitrates quickly turned a deep blue color while the low-nitrate sections developed either no color at all or only faint traces of blue.

For the above tests, sections were cut from the stems a few millimeters beneath the cuttings. From many cuttings representing several groups, sections from the middle and toward the tip were also taken. While these sections were being examined, each cutting was kept in a test tube of distilled water, and those that did not conform to the standard for the group were discarded later.

Four series of tomato cuttings were run. In each series the cuttings were as uniform in size and type as possible. Every cutting had a growing point at the tip and a node at the base. In order to make them dependent upon their own food reserves, they were rooted in the dark and in sand to which distilled water, or cultural solutions were added. These cultural solutions were added to the sand in two series for the purpose of determining the effect of the presence and the absence of nitrates. However, in these series nitrates became present in all lots in which cultural solutions were used, both in the sand and in the cuttings, and data concerning this phase of the investigations were of no value. No such difficulties were experienced when cuttings were rooted in sand with distilled water.

The results obtained in the four series are summarized in the following table. The roots were counted and measured 12 to 20 days after the cuttings were planted, depending upon the rapidity of root initiation.

TABLE I

Carbohydrates	Nitrates	Number of Cuttings	Average Weight Grams	Number Rooted	Average Number Roots per Cutting	Average Total length of roots per Cutting, Cm.
Low	High	163	.40	6	.055	.050
Low	Low	93	.38	4	.020	.007
High	High	144	.44	134	7.850	11.860
High	Low	112	.46	109	9.400	19.680

Two series of tradescantia cuttings were also run; these were rooted in nutrient solutions. No significant differences were discerned between cuttings in complete and those in no-nitrate solutions. Hence the figures obtained in the different solutions are grouped together.

TABLE II

Carbohydrates	Nitrates	Number of Cuttings	Average Weight Grams	Number Rooted	Average Number Roots per Cutting	Average Total length of roots per Cutting, Cm.
Low	High	117	.63	61	.91	.35
High	High	120	.73	120	6.40	8.98
High	Low	120	.72	120	6.50	9.44

The foregoing data quite clearly indicate the outstanding importance of carbohydrates in the production of roots by cuttings. This statement is not intended to minimize other factors associated with carbohydrates, but the fact is strikingly significant that whenever they were present in abundance roots were readily put forth. On the other hand, when carbohydrates were lacking, or were very low in the cuttings, roots did not develop. If the carbohydrate content was not too low, roots were initiated, but they made little growth.

The wide differences in root development that are noted above could not be secured by varying the nitrate content. Whether cuttings were high or low in nitrates, roots developed only when carbohydrates were abundant. Although root development is inconceivable without nitrogen, it is evident that the influence of carbohydrates dominated that of the nitrates. This greater importance of carbohydrates may be the logical consequence of their predominance in cell structure. Furthermore, the energy required in the production of new roots is probably derived more from carbohydrates than from nitrogenous compounds. In considering the influence of nitrates, it should be recognized that they may have functioned not directly, but indirectly, as a source of nitrogen which was synthesized into forms more directly concerned with plant metabolism. That nitrates are not directly used in the construction of new roots is indicated by the fact that these were freely produced when nitrates were lacking, both in the cuttings and in

sand or solutions, provided that carbohydrates were present. Such nitrogenous compounds as were essential to the formation of roots, to the extent developed, were evidently well provided for in the organic nitrogen compounds present in the cuttings.

In this connection it should be noted that only nitrate-free nutrient solutions had been applied for several days to the plants which yielded these low nitrate cuttings; both growth and color of the plants indicated a deficiency of nitrates. Hence it is evident that nitrogen need not be supplied to plants as the time approaches to secure cuttings. On the contrary, these investigations show that it might be better to withhold nitrates at this time since there was a consistent correlation between a high nitrate content and depression of root development when tomato cuttings were rooted in sand, the depression varying from 17 to 60 per cent with an average of 44 per cent. The data regarding the depressing influence of nitrates on tradescantia cuttings in solutions, are not so conclusive, and these results cannot be explained without further investigation.

The rather marked effect of a high nitrate content in depressing the rooting of cuttings in sand suggests that the nitrate content of plants may be an important factor in controlling the proportion of tops and roots. Generally, top growth has been greater than root growth when nitrates were abundant in nutrient solutions, and root growth greater when nitrates were low or lacking. Heretofore, there has been practically no evidence to show whether these top-root ratios were influenced by nitrates in the solution, or by the nitrogen in the plants. Turner (4) thought that increasing the amount of nitrates stimulated a greater use of carbohydrates in the top than in the roots. Gericke (1) suggested that long roots were related to a deficiency of nitrogen in solutions. The evidence presented in this paper suggests that nitrates within the plant, directly or indirectly, influence, in part at least, the proportion of tops to roots, and that a carbohydrate-nitrogen ratio favorable to root growth may be different from a ratio favorable to top growth.

These different ratios may be of fundamental importance in cuttage if the material behaves as did tomato; if as tradescantia, not. An abundance of cutting material could be obtained by supplying nitrates liberally. When this material has reached the proper size, nitrates perhaps should be withheld to encourage the best condition for rooting. That it would be disadvantageous to give nitrates continually to plants up to the time of taking cuttings, is shown in another test. Such plants produced an average of 7.5 cm. total length of roots, a striking contrast to 22.9 cm. produced by cuttings from plants which received very limited supplies of nitrates.

In this instance the cuttings producing the shortest total root length were from vigorously growing plants. This does not appear to confirm the statement made by Kains (2) that "vigorous health" as judged by appearance in the parent plant, is "the primary requisite for success with greenwood cuttings." Furthermore, the cuttings that rooted best in the other series were from plants of yellowish color and lacking in vigor, a condition associated with a high carbohydrate content.

Evidence was also obtained which suggests that nitrate-free media are best for rooting tomato cuttings. In another series, cuttings from potted plants were rooted in complete and nitrate-free solutions. These cuttings were high in carbohydrates and low in nitrates, and were run in duplicate lots of 10 cuttings each. The average total length of roots per cutting was as follows:

Cuttings rooted in complete cultural solution 16.1 cm.
Cuttings rooted in nitrate-free cultural solution 22.9 cm.

These results suggest that the low nitrate content of sand may be one reason why it has been found better than good soil for cuttings.

In addition to the root depressing effects already mentioned, it is possible that nitrates may prevent thickening and lignification of cell walls, as suggested by Krause and Kraybill (3), and thus make the cuttings more susceptible to injurious fungi. This effect may partly account for the rapid decay of herbaceous cuttings when placed in rich soil.

Data secured from tradescantia indicate that the initiation of roots at the nodes of this plant is not due to the greater accumulation of food reserves at these places, a concept mentioned by Kains (2). In the low carbohydrate plants there was no starch at the nodes although reducing substances were sufficiently abundant to start roots. On the other hand, the plants high in carbohydrates, starch, and also free reducing substances, were very abundant in the internodal areas as well as in the nodes, and yet roots were restricted to the latter. It seems highly improbable, therefore, that a greater concentration of carbohydrate food reserves was responsible for root development at the nodes only.

That firmness of stems may often be taken as an index of their fitness for cuttings insofar as the carbohydrate content is concerned, is indicated by the fact that the stems low in carbohydrates were soft and flexible in contrast to those high in carbohydrates which were firm and stiff. However, this condition should not be confused with firmness caused by the thickening and lignification of cell walls.

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Growth and Composition of Some Shaded Plants

By C. G. VINSON, *Experiment Station, Wooster, Ohio.*

A CONTINUATION of the work on shading horticultural plants, begun by Gourley at New Hampshire, and already reported on by Gourley and Nightingale, and by Kraybill was carried on at the Ohio Agricultural Experiment Station during the growing season of 1922 and 1923.

At the Ohio Station the cloth used for shading purposes was somewhat heavier than that used in the New Hampshire work; but the influence on fruiting and character of growth seems to have been much the same.

Plants used in the Ohio work were: apple, peach, cherry, currant, strawberry, Jerusalem cherry, geranium, tomato, lima bean, radish, chard, potato and young apple seedlings.

In the case of seedling plants, differences in growth were noted immediately after they were through the ground and before, it would seem, any appreciable amount of good material could be synthesised by the small chlorophyll bearing area. The difference in growth of such small plants was chiefly in length of hypocotyl, the distance from the surface of the soil to the cotyledons always being greater in the shade plot.

The growth of plants in the shade was characterized by greater length of internode, more slender stem, and leaves of larger area, but smaller cross section. The differences of growth were more marked in the case of potato, raspberry, blackberry, and bush lima bean, the latter becoming typical climbers in the shade. The fruiting of plants in the shade averaged uniformily less, excepting in the case of raspberry.

Comparison of analyses of plants in the sun and shade plots shows that in general the ratio of nitrogen to carbohydrate is higher in the shade plants than in those grown in the sun. The moisture content of plants in the shade plot was also higher.

The analyses of young lima bean plants just coming through the ground, show that both the carbohydrate and nitrogen content of the sun plants, stem portion, was a little higher, but the cotyledons of the sun plants are correspondingly lower in these constituents, so there has evidently been a difference in the rate of withdrawal and utilization of the reserve material of the cotyledons. The cotyledon of the shade plant developed more rapidly than that of the plants in the sun, so the more rapid utilization of the reserve materials in the cotyledons in the case of the sun plants must have been due to their more rapid root development.

Inability to find greater differences in the nitrogen, or carbohydrate content of spurs from the shaded and exposed portions of a Blenheim apple tree, where differences in growth were marked, leads one to question, somewhat, the accuracy of our present methods of analysis.

In general, however, the results obtained in shading horticultural plants at the Ohio Experiment Station, show there is a marked effect on fruiting and on vegetative growth, and that it is possible to correlate, partially at least, these differences with differences in chemical composition.

A Study of Protoplasmic Connections in Apple Tree Tissue

By J. S. BAILEY, *Agricultural College, Amherst, Mass.*

THIS address will be included in a bulletin of the Iowa Experiment Station.

A Proposed Key to Commercial Apples

By C. C. CARPENTER AND I. B. STAFFORD, *Syracuse University, Syracuse, N. Y.*

THERE is, at present, distinct need of a satisfactory means of recognizing unknown apple varieties. Since men first became interested in pomology, there have been countless attempts to classify, or describe, varieties so that they might be distinguished from one another. In fact almost everyone with a bent toward the study of systematic pomology has, at one time or another, attempted to make a classification, or key, to be used with some one of the common fruits, usually to find that it would not work except on paper, or that its use was so limited that it was of no value to anyone except the author. In the latter case however the result is worth the effort as such a key is a great aid to the recognition of some of the varieties with which the author is less familiar.

A study of the score or more keys so far published for the identification of apple varieties shows them to be of every conceivable form and degree of merit. The first keys are quite elementary in form, but the later keys show a development and gradual improvement which would seem to indicate that the faults and mistakes of previous attempts had been noted and attempts to avoid them been made. Some of the commoner faults noticed in the keys so far published are the following:

1. Use of characters which are quite variable.
2. Use of characters in which variations are hard to distinguish.
3. Attempt to include too many varieties.
4. Insufficient separation, that is, final groups too large.
5. Complex form making the use quite difficult.

In the formulation of the key here presented these defects were avoided as far as possible. The characters selected for use were those which were most consistently mentioned in available printed

descriptions and those which seemed most constant and most easily recognized in the fruit. Believing, as did Downing, that a key for all the varieties was impossible, and that one devised for some limited group would be more practical, the variety list was confined to those varieties which were found to be quoted in the files of trade journals and periodicals giving market quotations. More complete separation of the varieties was brought about by making a large number of classes and the careful selection of the characters to be used, so that a good proportion of the possible classes contained varieties. Simplicity of form was attained by reducing the key, so far as the major work of tracing down a variety is concerned, to a chart small enough to be contained on a double, or possibly a single printed page.

The characters selected for use are the following: (1) Flavor, sour or sweet; (2) Longitudinal form, conic, round, oblate and oblong; (3) Cross section, regular or irregular; (4) Cross section, round or ribbed; (5) Skin color, self colored or striped; (6) Flesh color, white, yellow, green or red; (7) Carpels, tufted or not tufted. A brief discussion of these characters will perhaps not be out of place.

Recognizing the fact that fine distinctions of flavor are impossible to describe so that they are clear to a reader, the varieties used are separated into two groups only, sweet and sour. Any apple from the sourest to the mildest subacid is considered sour, the rest sweet. Those varieties on the border line, or which apparently turn sweet with increasing maturity are placed in both classes.

The classes included under longitudinal form were those made up of the four primary shapes, conic, round, oblate and oblong, and combinations of these, such as oblong-conic, round-oblate, and so on. Most of the apples studied were found to have one of these combination forms rather than a simple primary form. Many varieties had to be placed in more than one group as to form because of differences due to different growing conditions, or to natural variability.

The cross section classes are self explanatory. In judging shape, either longitudinal or cross section, it was found to be much simpler if the fruit was halved along the proper axis and the shape of the cut surface considered rather than that of the whole apple.

Two general classes of skin color are recognized, striped and self colored. The latter is also divided into blushed and not blushed. Any apple with red markings which is not pure blushed is considered striped, regardless of whether the markings are mottled, striped or splashed.

Four different flesh colors are considered, white, yellow, green and red. When any tinting of yellow, green or red is present, that color is considered as the flesh color. This character was found to be one of the most constant for a variety although rather difficult to judge accurately. This difficulty is minimized if the cut surface is placed beside a piece of white paper immediately after cutting, when the tinting, if present, shows quite plainly.

Tufts appear as white, cottony strips across the carpel. This character of apple is perhaps the least constant of all those used in the key so that it is not always safe to judge a variety on this point from a single specimen only. Care should also be taken to differentiate between true tufts and cracks which often appear in the carpels.

All the work in the selection of characters and location of varieties in the key was first done from the available printed descriptions. Actual specimens of the varieties used were later obtained and the entire key carefully revised, and the location of some varieties changed as was found necessary.

The key made from the above characters is in three parts. These are the chart, the group numbers with the varieties contained in them, and the supplementary keys.

The first step in locating a variety is to find its group number on the chart. At the top of the chart are located the possible pure and combination longitudinal shapes, each of which is further divided as to regularity, or irregularity, of cross section. This gives 18 columns in which the group number of a particular variety may be located. On the left side of chart the first division is that of round, or ribbed cross section. Each of these is again divided into two groups according to skin color, striped or self colored, the self colored being further divided into blushed and not blushed. The groups as to skin color are still further divided into the four groups of flesh color, each of these being separated into tufted and not tufted carpels. This gives 48 lines across the sheet and divides it into 864 squares. The squares are numbered serially down the columns begining at the top of the left hand column, but the numbers being placed only in those squares in which one or more varieties are located. In the list of group numbers and varieties, the sweet and sour apples are kept separate, thus doubling the number of classes appearing on the chart, and making a possible total of 1728 classes into which apples with the proper characteristics may be placed. This is the largest number yet included in any one key. As new varieties are included which may fall in groups not already listed the proper number can be added with little difficulty and without affecting materially the rest of the chart.

Tracing down an apple on the chart consists in locating its characters at the top and side of the key. This gives a line and a column which are traced to the point where they cross. In that square is found the number of the group in which the variety is included.

The next step is to turn to the list of group numbers and find the number corresponding to the one previously located on the chart. Under this number will be found the varieties included in this group. If more than two varieties are listed under one number, a third step is necessary. This is done by the use of the supplementary keys which follow the list of group numbers.

Wherever possible separation in the supplementary keys was made under the following plan:

I. Marginal stamens
II. Median stamens
III. Basal stamens

A. Dots conspicuous
B. Dots inconspicuous
  1. Stem short
  2. Stem long

Where this form did not give sufficient differentiation, or where it could not be used, other characters which were outstanding for a variety, were used.

As proof of the fact that the characters selected for use in this key are satisfactory for purposes of differentiating varieties, consider the following data on separation as made by the chart alone, without the aid of the supplementary keys. The key contains 125 varieties listed in 219 groups, (since many apples appear in more than one group due to the fact that specimens are not always uniform in their characteristics), of which 186 are sour groups and 33 are sweet. From the chart itself the following groupings are made:

Sour Apples		Sweet Apples	
Number in group	*Number of groups*	*Number in group*	*Number of groups*
1	120	1	31
2	39	2	2
3	14		—
4	5		33
5	2		
6	3		
8	2		
13	1		
	—		
	186		

This shows clearly that small groups are the rule, since 69 per cent of the groups contain but a single apple, and 18.7 per cent contain but two. The use of the supplementary keys then, is reduced to a low point.

The key here presented has attempted to avoid some of the commoner faults of previous keys, and seems to the authors to have the following advantages:

1. The entire key, for the location of a group, is on one page.
2. The number of possible groups is more than that of any other key. This allows of greater separation.
3. The characters used were selected as being the most frequently mentioned in printed descriptions and most easily recognized in the fruit.
4. The variety list includes only the varieties which are listed in trade journals as commercial. This reduces the number to be separated in the key and still includes those varieties which are most commonly encountered.
5. Varieties may be placed in more than one group without

KEY TO COM

Cross-Section	Skin Color		Flesh Color	Carpel	Conic Reg.	Conic Irr.
ROUND	SELF-COLORED	BLUSHED	White	Tufted		
				Not Tuft.		
			Yellow	Tufted		
				Not Tuft.	4	
			Green	Tufted		
				Not Tuft.		
			Red	Tufted		
				Not Tuft.		
		NOT BLUSHED	White	Tufted		
				Not Tuft.		
			Yellow	Tufted		
				Not Tuft.		
			Green	Tufted		
				Not Tuft.		
			Red	Tufted		
				Not Tuft		
	STRIPED		White	Tufted	17	
				Not Tuft.	18	
			Yellow	Tufted	19	
				Not Tuft.	20	
			Green	Tufted		
				Not Tuft.		
			Red	Tufted		
				Not Tuft.		
RIBBED	SELF-COLORED	BLUSHED	White	Tufted		
				Not Tuft		
			Yellow	Tufted		
				Not Tuft		
			Green	Tufted		
				Not Tuft.		
			Red	Tufted		
				Not Tuft		
		NOT BLUSHED	White	Tufted		
				Not Tuft	34	
			Yellow	Tufted		
				Not Tuft.		
			Green	Tufted		
				Not Tuft.		
			Red	Tufted		
				Not Tuft.		
	STRIPED		White	Tufted		
				Not Tuft.	42	
			Yellow	Tufted	43	91
				Not Tuft.	44	
			Green	Tufted		
				Not Tuft.		
			Red	Tufted	47	
				Not Tuft.	48	

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MERCIAL APPLES

Conic						Round						Oblate		Oblong	
Round		Oblate		Oblong		Round		Oblate		Oblong					
Reg.	Irr.	Reg.	Irr.	Reg.	Irr.	Reg.	Irr.	Reg.	Irr.	Reg.	Irr.	Reg.	Irr.	Reg.	Irr.
				290		386	434		530				722		
99	147	195	243			387	435	483					723		
100		196		292		388	436	484			628	676			
								485							
104				286			440	488	536						
105						393									
106		202													
107				299		395		491						779	
108		204				396	444	492			636	684			
113	161						449		545						
114		210	258	306		402	450	498	546						
115	163	211		307		403	451	499	547				739		
116		212	260	308		404	452	500	548	586	644		740		
117		213													
118								502							
120							456	504	552	600					
121		217		313				505							
				314				506				698			
	171	219	267		363	411	459	507	555		651	699	747		843
124			268	316	364	412			556						
				320											
129	177	225		321	369										
130			274	322				514				706	754		
131	179		275	323	371	419	467	515	563		659		755	803	851
				324	372	420	468	516			660				
137	185	233	281			425		521							
138		234		330				522	570			714	762		
139	187	235	283	331	379	427	475	523	571		667	715	763		859
140	188			332		428			572				764		860
	190		286												
143		239				431		527							
	192	240		336		432		528	576			720			

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difficulty thus taking care of variations commonly found in varieties.

6. Separation is more complete than in most previous keys.
7. The key can be understood and used by one with little or no training in pomology.
8. The addition of a new variety is accompanied by a minimum of change in the rest of the key.
9. Its form is simple and can be adapted for use with other fruits or for regional keys of varieties.
10. It presents a new idea in key formation.

This last point is considered by the authors as probably the most important. They realize that the key as it now stands is not perfect, and that despite the care with which it was first made and the numerous checkings which the variety placings have received, there is still the possibility of minor errors in the location of varieties. However, the key form is new. It is simple and easy to use, and it is with the hope that the idea of key formation here presented may be of some value to others interested in this type of work that this paper is offered. The success of this key itself is also, of course, of considerable interest.

Sour Apple Groups

4	Gano
17	Cooper Market
18	Ben Davis
19	Cooper Market
20	Alexander
	Winesap
42	Ben Davis
43	Delicious
44	Alexander
	Winesap
47	Williams
48	Canada Baldwin
91	Ralls
	Stayman Winesap
99	Fallawater
	Limbertwig
100	Jonathan
	King David
104	King David
106	Swazie
108	Swazie
113	Cooper Market
114	Ben Davis
	Stump
	Tetofski
	Wealthy
115	Cooper (Market)
	Ingram
	Magog
	Minkler
	Pennock
	Ribston
	Salome
	Walbridge
116	Alexander
	Cox Orange
	Jefferis
	Jonathan
	Magog
	Missouri Pippin
	Pennok
	Red Canada
	Rome Beauty
	Stump
	Twenty Ounce
	Willowtwig
	Winesap
117	Minkler
118	Plumb Cider
	Red Canada
	Willowtwig
120	Wealthy
124	Gilpin
	Jonathan
	Opalescent
129	Yellow Transparent
130	MacMahon
131	White Pearmain
137	Melon
	Red Astrachan
138	Ben Davis
139	Deacon Jones
	Melon
	Northern Spy
	Sops of Wine
	Stark
140	Alexander
	Benoni
	Jonathan
	Mother
	Northern Spy
	Winesap
143	Red Astrachan
	Sops of Wine
147	Baldwin
161	Bismarck
	Hubbardston
163	Baldwin
	Bethel
	Hubbardston
	Smith Cider
171	Banana
	Spitzenburg
177	Titus Pippin
179	Titus Pippin
185	Bietigheimer
187	Esopus
	Stayman Winesap
188	Scott
190	Red Canada
192	Scott
195	Limbertwig
196	Patten
202	Swazie
204	Patten
	Swazie
210	Shiawassee
211	Ingram
	Minkler
	Ribston
212	Cox Orange
	Jefferis
213	Minkler
217	Boiken
219	Arkansas
	Huntsman
225	Yellow Transparent

233 Detroit Red
Melon
234 Haas
235 Arkansas
Melon
239 Detroit Red
240 Haas
243 Monmouth
258 Hurlbut
260 Hurlbut
260 Hibernal
Hurlbut
267 Monmouth
268 Peck
274 Primate
275 Roxbury
281 Bietigheimer
283 Ralls
286 Red Canada
290 Red June
292 Jonathan
296 Red June
299 Porter
300 Sheriff
Stump
407 Black Gilliflower
308 Jonathan
Stump
314 Red June
316 Gilpin
Jonathan
320 Red June
323 White Pearmain
324 Ortley
330 Chenango
St. Lawrence
331 Black Gilliflower
Deacon Jones
Delicious
Northern Spy
332 Jonathan
Northern Spy
336 St. Lawrence
363 Banana
Canada Reinette
Esopus
Yellow Bellflower
364 Golden Delicious
369 Titus
371 Titus
Yellow Bellflower
372 Golden Delicious
379 Esopus
386 Longfield
387 Arkansas Black
Fallawater
388 Oliver
395 Golden Russet
402 Fameuse
Sheriff
403 Arkansas Black
Magog
Salome
Sutton
Walbridge
Westfield
404 Magog
Missouri
Oldenburg
Oliver
Rome Beauty
Twenty Ounce
411 Swaar
412 Gilpin
419 Swaar
425 Red Astrachan
427 Kinnard
Sops of Wine
Stark
428 Benoni
Mother
431 Red Astrachan
Sops of Wine
432 Canada Baldwin
434 McIntosh
435 Baldwin
436 Golden Reinette
440 McIntosh
444 Northwestern
Greening
449 Pewaukee
Wolf River
450 McIntosh
451 Baldwin
Bethel
Wolf River
452 Golden Reinette
456 McIntosh
459 Holland
468 Northwestern
Greening
475 Blue Pearmain
483 Lawver
Mann
484 King David
Oliver
R. I. Greening
485 Lawver
488 King David
491 Golden Russet
Mann
492 R. I. Greening
498 Sheriff
Tetofski
Wealthy
499 Pennock
Sutton
500 Cox Orange
Jefferis
Jewett Red
Oldenburg
Oliver
Pennock
Willowtwig
502 Willowtwig
504 Wealthy
505 Boiken
506 Early Harvest
507 Arkansas
Huntsman
Swaar
514 Early Harvest
515 Swaar
521 Detroit Red
522 St. Lawrence
523 Arkansas
527 Detroit Red
528 Canada Baldwin
St. Lawrence
530 McIntosh
536 McIntosh
545 Bismarck
Wolf River
546 Hurlbut
McIntosh
547 Blenheim
Bonum
Rambo
Wolf River
548 Hibernal
Hurlbut
Jewett Red
552 McIntosh
555 Canada Reinette
Holland
Washington Royal
556 Peck
563 Washington Royal
570 Wagener
571 Blue Pearmain
Gravenstein
Smokehouse
Tompkins King
York Imperial
572 Akin
Buckingham
Scott
576 Scott
596 Rome Beauty
628 Golden Reinette
636 Northwestern
Greening
644 Golden Reinette
651 Gideon
Holland
Yellow Bellflower
659 Yellow Bellflower
660 Northwestern
Greening
667 Tompkins King
York Imperial
676 Patten
684 Patten
698 Early Harvest
699 Arkansas
706 Early Harvest
714 Haas
715 Arkansas
Kinnard
720 Haas
722 Lady
Maiden Blush

723 Monmouth
739 Blenheim
Rambo
740 *Hibernal*
747 Banana
Canada Reinette
Monmouth
754 Primate
755 Roxbury
762 Wagener
763 Gravenstein
Smokehouse
764 Akin
Buckingham
Domine
779 Grimes
Porter
803 Grimes
843 Esopus
851 Yellow Newtown
859 Esopus
860 Domine

Sweet Apple Groups

34 Autumn Bough
43 Delicious
99 Fallawater
105 Tolman
107 Tolman
115 Hogg Island
116 Hogg Island
121 Bough
129 Bough
161 Hubbardston
163 Hubbardston
179 Pumpkin Sweet
211 Hogg Island
212 *Hogg Island*
313 Bough
321 Bough
322 Autumn Bough
331 Delicious
364 Golden Delicious
372 Golden Delicious
387 Baker Sweet
Fallawater
393 Tolman
395 Baker Sweet
Tolman
396 *Golden Sweet*
420 Golden Sweet
427 Bailey Sweet
467 Pumpkin Sweet
483 Baker Sweet
491 Baker Sweet
492 Golden Sweet
516 Golden Sweet
555 Washington Royal
563 Washington Royal

Supplementary Keys

114

I. Dots conspicuous
A. Very short stem
1. Fleshy pistil point …………………… Stump
II. Dots inconspicuous
A. Flesh pithy and coarse
1. Fleshy pistil point
a. Winter apple …………………… Ben Davis
B. Green skin with few red stripes
1. Submerged dots
a. Summer apple …………………… Tetofski
C. Bright attractive red
1. Narrow, smooth and abrupt basin
a. Fall apple …………………… Wealthy

115

I. Basal Stamens
A. Stem short
1. Pubescent stem …………………… Ribston
2. Large open calyx …………………… Ingram
3. Pubescent calyx …………………… Pennock
B. Long slender stem …………………… Salome
II. Median to marginal stamens
A. Stem short
1. Submerged areolar dots
a. Prevailing effect yellow …………………… Magog
2. Small, yellow-gray dots
a. Prevailing effect pinkish red …………………… Minkler
3. Fleshy pistil point …………………… Walbridge
B. Stem long …………………… Cooper Market

116

I. Marginal stamens
A. Dots conspicuous
1. Pubescent calyx and stem …………………… Red Canada
2. Greenish dull red skin …………………… Willowtwig
3. Small white dots …………………… Winesap
4. Mostly yellow skin …………………… Magog
B. Dots inconspicuous

1. **Flaring green cavity** .... **Rome Beauty**
2. **Acute cavity** .... **Jefferis**

II. Median stamens
A. Dots conspicuous
1. **Deep abrupt wrinkled basin** .... **Missouri**

III. Basal stamens
A. Dots conspicuous
1. **Pubescent calyx** .... **Pennock**
2. **Fleshy pistil point** .... **Stump**
3. **Calyx tube *to core*** .... ***Twenty Ounce***
4. **Yellow *orange under color*** .... ***Cox Orange***

B. Dots inconspicuous
1. **Short thick stem** .... **Alexander**
2. **Long slender stem** .... **Jonathan**

118

I. Dots conspicuous
A. Calyx and stem pubescent .... **Red Canada**
B. Green and dull red skin color .... **Willowtwig**

II. Dots inconspicuous
A. Extremely marginal stamens .... **Plumb Cider**

124

I. Dots conspicuous
A. Short stem
1. **Calyx lobes large and fleshy**
   a. **Season February to June** .... **Gilpin**
2. **Calyx lobes small**
   a. **Season November to February** .... **Opalescent**

II. Dots inconspicuous
A. Long slender stem .... **Jonathan**

139

I. Marginal stamens
A. Dots conspicuous
1. **Short wide calyx tube** .... **Sops of Wine**

II. Median to marginal stamens
A. Dots inconspicuous
1. **Fleshy pistil point** .... **Melon**

III. Median to basal stamens
A. Dots conspicuous
1. **Deep red with whitish bloom**
   a. **Leafy calyx** .... **Deacon Jones**
2. **Pale green with dull red overcolor**
   a. **Fleshy pistil point** .... **Stark**

IV. Basal stamens
A. Dots inconspicuous
1. **Yellow with pink overcolor** .... **Northern Spy**

140

I. Marginal stamens
A. Short stem
1. **Dark mottled red and green** .... **Winesap**

B. Long stem
1. **Golden yellow covered with bright deep red** .... **Mother**

II. Basal stamens
A. Short stem
1. **Smooth basin**
   a. **Red and green striped** .... **Alexander**
2. **Wrinkled basin** .... **Benoni**

B. Long slender stem
1. **Red blush over yellow** .... **Jonathan**
2. **Yellow with pink overcolor** .... **Northern Spy**

163

I. Marginal stamens
  A. Pinkish red over yellow
    1. Leafy calyx lobes ....Smith Cider
  B. Very short stem
    1. Deep acute cavity ....Hubbardston
II. Median to basal stamens
  A. Pubescent calyx ....Bethel
III. Basal stamens
  A. Fleshy pistil point ....Baldwin

211

I. Median to marginal stamens
  A. Short stem
    1. Prevailing effect pinkish
      a. Yellow gray dots ....Minkler
II. Basal stamens
  A. Short pubescent stem ....Ribston
  B. Large open calyx ....Ingram

331

I. Dots conspicuous
  A. Five distinct crowns at apex
    1. Almost sweet ....Delicious
  B. Deep red with whitish bloom
    1. Leafy calyx ....Deacon Jones
II. Dots inconspicuous
  A. Dull purplish red ....Black Gilliflower
  B. Yellow with pinkish red overcolor ....Northern Spy

363

I. Dots conspicuous
  A. Dull yellow with decided blush ....Canada Reinette
  B. Lemon yellow to white with occasional bronze blush
    1. Pubescent calyx ....Yellow Bellflower
  C. Deep yellow covered with bright attractive red ....Esopus
II. Dots inconspicuous
  A. Waxy yellow with frequent pale blush
    1. Suture line from basin to cavity ....Banana

403

I. Marginal stamens
  A. Dots inconspicuous
    1. Dark red to black ....Arkansas Black
II. Median to marginal stamens
  A. Dots conspicuous
    1. Stem short ....Magog
    2. Fleshy pistil point ....Walbridge
III. Median stamens
  A. Dots inconspicuous
    1. Pubescent calyx ....Sutton
IV. Basal stamens
  A. Dots conspicuous
    1. Dull green and red ....Salome
    2. Deep yellow and dull red ....Westfield

404

I. Marginal stamens
  A. Dots inconspicuous
    1. Flaring green cavity ....Rome Beauty
II. Median to marginal stamens
  A. Submerged areolar dots
    1. Prevailing effect yellow ....Magog
III. Median stamens
  A. Dots conspicuous

1. Deep abrupt and wrinkled basin ....Missouri
B. Dots inconspicuous
1. Attractive striped ....Oldenburg

IV. Basal stamens
A. Dots conspicuous
1. Calyx tube to core ....Twenty Ounce
2. Deep dull dark red ....Oliver

427

I. Marginal stamens
A. Dots conspicuous
1. Season December to March ....Kinnard
B. Dots inconspicuous
1. Season August to October ....Sops of Wine

II. Median to marginal stamens
A. Dots conspicuous
1. Pale green with dull red
a. Fleshy pistil point ....Stark

451

I. Median to basal stamens
A. Pubescent calyx ....Bethel
B. Very large size ....Wolf River

II. Basal stamens
A. Fleshy pistil point ....Baldwin

484

I. Dots conspicuous
A. Deep bright red ....Oliver

II. Dots inconspicuous
A. Deep bright red ....King David
B. Deep bright green with occasional slight bronzing ..R. I. Greening

498

I. Dots conspicuous
A. Season December to February ....Sheriff

II. Dots inconspicuous
A. Green with few red stripes
1. Summer apple ....Tetofski
B. Bright attractive red
1. Fall apple ....Wealthy

500

I. Marginal stamens
A. Dots conspicuous
1. Green and dull red skin ....Willowtwig
B. Dots inconspicuous
1. Acute cavity ....Jefferis

II. Median stamens
A. Dots conspicuous
1. Dots pale yellow or white ....Jewett Red
B. Dots inconspicuous
1. Attractive striped ....Oldenburg

III. Basal stamens
A. Dots conspicuous
1. Pubescent calyx ....Pennock
2. Deep, dull, dark red ....Oliver
3. Yellow orange undercolor ....Cox Orange

507

I. Dots conspicuous
A. Slender stem
1. Green or yellow ....Swaar

II. Dots inconspicuous
A. Stamens marginal

1. Yellow green with orange red blush ....Huntsman
B. Stamens median
1. Green or yellow overspread with dull red ....Arkansas

547

I. Short stem
A. Large wide open calyx ....Blenheim
B. Small closed calyx ....Rambo
C. Very large size ....Wolf River
II. Long stem
A. Large closed calyx ....Bonum

548

I. Marginal stamens
A. Dots inconspicuous
1. Fleshy pistil point ....Hurlbut
II. Median stamens
A. Dots conspicuous
1. Deep red ....Jewett Red
B. Dots inconspicuous
1. Greenish yellow with bronze and dull crimson ......Hibernal

555

I. Brisk subacid
A. Pubescent calyx
1. Dots often submerged ....Holland
II. Subacid
A. Yellow with decided red blush ....Canada Reinette
III. Nearly Sweet
A. Raised dots
1. Green cavity ....Washington Royal

571

I. Dots conspicuous
A. Light yellow and red
1. Oblique axis ....York Imperial
B. Bright attractive red over yellow ....Tompkins King
C. Greenish yellow mottled with dull red ....Smokehouse
D. Abundant purplish bloom ....Blue Pearmain
II. Dots inconspicuous
A. Golden yellow with broken red stripes ....Gravenstein

572

I. Median to marginal stamens
A. Very short stem
1. Pubescent calyx ....Scott
II. Median stamens
A. Long stem ....Akin
III. Median to basal stamens
A. Short thick stem ....Buckingham

651

I. Short stem
A. Pubescent calyx
1. Dots often submerged ....Holland
II. Long stem
A. Dots conspicuous
1. Median to basal stamens
a. Pubescent calyx ....Yellow Bellflower
B. Dots inconspicuous
1. Marginal to medium stamens ....Gideon

747

I. Dots conspicuous
A. Dull yellow with decided blush ....Canada Reinette
B. Calyx large, leafy and pubescent ....Monmouth

II. Dots inconspicuous
  A. Waxy yellow with frequent pale blush
    1. Suture line from basin to cavity ....Banana

764

I. Median to marginal stamens
  A. Long stem
    1. Basin pubescent ....Domine
II. Median stamens
  A. Long stem ....Akin
III. Median to basal stamens
  A. Short thick stem
    1. Calyx pubescent ....Buckingham

The Effect of Temperature on the Potato Plant*

By JOHN BUSHNELL, *Experiment Station, Wooster, Ohio*

A LARGE group of the vegetables are classified as cool season crops, with an optimum temperature considerably below the average summer temperatures of most of the United States. With this fact in mind, a physiological study of the effect of temperature, particularly temperatures above the optimum, has been carried on with the potato.

The potato was selected for this problem not primarily because of its economic importance, but rather because its general physiology is better established than that of the other cool climate vegetables. From surveys and census records it is clear that the largest yields of potatoes are produced in cool seasons and in regions of low summer temperatures. From the physiological view point, the most obvious effect of high temperatures on this crop is the reduction in the amount of stored starch. In outlining a physiological problem, therefore, the first point to investigate was the effect of temperature on the photosynthesis, translocation, and oxidation of the carbohydrates.

To secure the temperatures desired, four glass chambers were set up in the greenhouse and fitted with electrical thermostats and humidity controls. These were first available during the summer of 1922. As the temperature in the greenhouse at this time was far above the optimum for potatoes, and no adequate method of cooling the chambers was available, the temperature study was postponed and a preliminary experiment conducted on the effect of different humidities at these high temperatures. This preliminary study was run at 30°C. with relative humidities at approximately 50, 66 and 99 per cent. The results may be summarized by simply stating that the growth of the plants in all three chambers was weak and spindly, typical high temperature effects, without any appreciable influence from the various humidities.

The study of the effect of various temperatures was taken up

*This work was carried out while the writer was associated with the Minnesota Experiment Station. It is published with the approval of the Director as Paper 440 of the Journal Series of the Minnesota Agricultural Experiment Station.

the following spring. At this season of the year it was possible to maintain sufficiently low temperatures in the greenhouse and at the same time have sunlight nearly equal to that of the normal outdoor growing season. For this experiment, tubers of Early Ohio were planted in pots in ordinary sandy soil. As soon as the plants were above the surface, they were divided into four lots and placed in four chambers operating at 20°, 23°, 26° and 29°C. with relative humidity at about 60 per cent. There was space for 20 plants in each chamber. The temperatures were not maintained strictly at the desired points, for each day the chambers were open several minutes while the plants were watered and measured, and occasionally the heating units failed to operate for short periods. However, the control of the temperature was sufficiently accurate to produce distinct and consistent differences in the appearance of the plants. These differences were most apparent in the leaves which were decidedly smaller at the two higher temperatures. The most striking effect was evident when the plants were examined at the close of the experiment, shortly after the blossoming period. The plants at 20°C. had produced one or more tubers per plant, while at the higher temperatures not a single plant was found with more than rudimentary tubers.

Samples were taken for chemical analysis at intervals during the progress of the experiment. In addition to these, qualitative tests were made at different times of the day, at various stages of growth, to determine the nature and relative quantity of carbohydrates in the leaves. Reducing sugars and sucrose were abundant at all times, but surprisingly, starch was not detected in the leaves at any stage. This absence of starch may have been due to the artificial conditions of the chambers, such as the reduction of light, or it may be the normal condition of young potato plants in the field.

The quantitative analyses showed considerable fluctuation in the amount of soluble sugars, but no significant differences that could be directly attributed to temperature. It appears from the data that light was the more important factor, for the plants in the chambers at the ends of the bank of four showed consistently higher amounts of soluble sugars per gram of leaf, and were probably better lighted than the central chambers. Although temperature produced no appreciable effect on the amount of sugar per unit weight of leaf, it indirectly affected the amount through its effect on the size of leaves. With the smaller leaves at the higher temperatures there was a corresponding reduction in the sugar content of the plant as a whole.

The measurements of respiration, on the other hand, showed a consistently higher production of carbon dioxide at the higher temperatures. After days of high light intensity the carbon dioxide respired during the night was distinctly greater at the three higher temperatures. In general the respiration at these temperatures accounted for more carbon than was present in the form of soluble sugar at sunset. As a specific illustration the data from a set of plants, 51 days after planting, following a day of bright sunlight, May 26, 1923, are presented in Table I.

TABLE I

*Effect of Temperature on the Respiration of Potato Plants**

Temperature of plants, Centigrade	20 mg.	23 mg.	26 mg.	29 mg.
Soluble sugar in leaves. Sample 1. 5:00 P. M.	48.1	24.2	32.9	29.5
Sample 2. 6:30 P. M.	30.3	20.7	34.6	26.7
Average	39.2	22.5	33.7	28.1
Soluble sugar in corresponding weight stems	89.6	52.4	105.8	67.4
Total soluble sugar per 10 grams leaves	128.8	74.9	139.5	95.5
Respired 7:00 P. M. to 5:00 A. M. Glucose equipment	81.5	95.8	93.5	115.5
Soluble sugar in leaves at 5:00 A. M.	9.3	8.0	15.3	12.3
Soluble sugar in stems at 5:00 A. M.	57.1	18.5	99.1	32.8
Respiration plus total sugar at 5:00 A. M.	147.9	122.3	207.9	160.6
Amount drawn from the insoluble reserves	19.1	47.4	68.4	65.1
Tubers on plants	Present	Absent	Absent	Absent

*Calculated to the glucose equivalent of 10 grams green weight of leaves.

The determinations of sugar in the evening are from composite samples of three plants to each sample. The respirations, however, are from single plants and these plants were preserved for analysis at the close of the respiration period at 5:00 a. m.

The figures in the table are arranged to show the total soluble sugar per 10 grams of leaves at sunset, the glucose equivalent of the carbon dioxide given off at night and the residual sugar at sugar per 10 grams of leaves at sunset, the glucose equivalent of in the morning is greater than the soluble sugars of the previous evening, that is, some reserve carbohydrate has been drawn upon. And the respiration being greater at the three higher temperatures the amount of reserve carbohydrate consumed by these plants is significantly greater. Thus these data show an excellent correlation between the draft on the higher carbohydrates during the night and the failure to produce tubers.

After cloudy days of low light intensity a number of respiration determinations showed that the rate of carbon dioxide emission during the first part of the night, was much the same as after bright days, but during the latter part of the night there was a decline in the rate, particularly evident at the higher temperatures, indicating that a deficiency of available carbohydrate had become a limiting factor. Thus, the evidence at hand suggests that at temperatures above the maximum for tuber production the increase in the rate of respiration consumes the carbohydrates that at lower temperatures are stored in the tubers.

Summary

In this study of potato plants under approximately controlled greenhouse conditions, humidity had no effect on the growth of the plants, but temperature had a striking effect. The maximum temperature at which Early Ohio potatoes produced tubers was between 20° and 23°C. At 23°C. and above, the failure to produce tubers is attributed to an increase in the rate of respiration, thus consuming the carbohydrates that at lower temperatures are stored in the tubers.

Need of a National Conference for the Standardization of Horticultural Instruction, Research and Extension Work

By J. C. Blair, *University of Illinois, Urbana, Ill.*

EDUCATIONAL organizations, as well as business organizations, are beginning to realize that too elastic and widely varying methods of teaching and practice are injurious; injurious both to the student and to the teacher.

Each horticultural group, or division, is working along its own particular line; each thinking that its methods are better than the methods of any other group; each striving to excel over its

neighbor. And so, today, horticultural teaching and horticultural practice are not at all uniform, but are in a more or less chaotic state. The task of standardizing business practices is difficult, but even more difficult is the standardizing of the instruction, the research, and the extension work, in this field of endeavor; for, we must attend to the technical or theoretical side of the problem as well as the practicable. Then, too, our standards must be appreciated and our teachings practiced by the horticultural industries if they are to be worth while. Without a moment's hesitation, we all agree, I am sure, that it is desirable to have accepted standards in the growing, grading, storing, packing, marketing, advertising, nomenclature, and fixed terms of sale, but have we given any constructive thought to the standardization or unification of effort in horticultural instruction, in the great field of horticultural research, or in the extension work?

When we purchase nursery stock we know exactly what we want, but do we know what the results will be when the stock is planted? The commercial buyer is often trusting to faith alone. And so in horticultural instruction; you know how you want your boy trained, but unless you choose the man with known training, experience, and personality as teacher, will he be sufficiently trained to enter this large and lucrative field of endeavor? For instance, are the terms, trade practices, grading tables, etc. found to be uniform in the various institutions in any particular section of the country? For the most part they are not. Should the trained horticulturist be limited to a certain region? Certainly not.

It should be our aim as educators to try to elevate standards of professional instruction and horticultural methods at all institutions offering professional instruction, and to promote relations between such institutions and the profession in general. How can we do this? Shall we institute exchange professorships, or lecture series, or scholarships or summer travel? Shall we conference together and attempt to unify our methods and our practices? I sincerely hope we may!

To be successful in our horticultural programs we must recognize the fact that knowledge is universal; that instruction, or research knows no state, or even national boundaries; that a contribution to science is a contribution to the knowledge of the whole civilized world. Often a more favorable environment for a particular horticultural problem may be found in an adjoining state, and if such conditions exist it is a part of economy and efficiency to locate the work there if it is at all possible to do so.

We must also recognize leadership. A person of vision, of inquiring mind, imbued with the real spirit of the scientist (which is public service, the service of mankind) is the only capable leader in the investigational field of horticulture.

I am tempted to compare most of our horticultural departments in this country, with their feeling that each has the best department on earth, to the man who is interested only in his own little family, or his own individual business. Is it not often only a reflection of his interest in himself? He should love his work, he should feel loyalty and self-sacrificing interest in it;

but, he should also have that larger interest in mankind, or in civilization, if you please. And he should also take an interest in other departments of horticulture, horticultural industries or allied trades. Each should be vitally interested in the other, because even the little affairs of one department depend upon what happens all over the earth. Each of us is interested in his own little corner, in his own importance. And that is right, but we should, also, look over our own back yard, across the neighbor's, and even across the ocean to other countries. Then we may become worthwhile citizens in our profession. A prosperous department brings happiness and a sense of comfort, but to contribute to the world's work is something which a man may well give all that he has.

And to repeat: (1) There is the individual department, the concern for which is our original duty, (2) There are neighboring institutions, calling for honest cooperation, (3) There is the nation, and nations, demanding national and international intellectual horticultural interest.

When these things can be done, then our minds, hearts, and hands, will be really working, and cooperatively. Let us get together and talk some of these things over. If you think the idea of a National Horticultural Conference a good one, then let us get busy and have one. Meet if you like in Urbana. We will be glad to have you. But meet! Meet somewhere!

The Fruiting Habit of the Squash*

By W. T. Tapley, *Pennsylvania State College, State College, Pa.*

THE study of exact details of plant growth, of plant anatomy, and of plant response, are fundamental to practices intended to increase the yield of vegetable crops. To increase yields of squash either more efficient cultural methods must be used, or improved varieties established through selection, or by crossing existing lines in the hope that new combinations of characters will result. Yield records of many varieties and strains are available, but there are few published records that indicate the relation of blossom habit to yield. For several seasons at harvest time it was observed that the individual fruits on a plant varied somewhat in size, shape and to a lesser extent in appearance. Since the squash plant produces blossoms through a period of from five to eight weeks we may expect variation in the fruits which have had varying lengths of time to mature between pollination of the blossom

*This work was planned and carried up to harvest time while the writer was a member of the Horticultural Department of the University of Minnesota. The writer is indebted to Basil Burrell and P. H. Wynne for the collection of data during the season and at harvest time. This paper is published with the approval of the Director as Paper No. 441 of the Journal Series of the Minnesota Agricultural Experiment Station.

and occurrence of frost. This project was planned to secure statistical data on blossoming and specifically it was hoped that it would have a bearing on the following questions.

1. To what extent do varieties or strains of squash differ in the total number of female blossoms produced per plant as well as in the percentage of those flowers which produce fruits?

2. To what extent do varieties or strains differ in respect to the period in the growth of the plant during which pistillate blossoms are produced and during which fertilization of these blossoms occur?

3. To what extent does the time that the blossom is open and is fertilized influence the weight and shape of the resulting squash?

The choice of varieties to use in crossing work and changes in cultural operations, insofar as time of planting is concerned, should be at least partially governed by statistical data that would answer the above questions.

Papers by Bushnell (1) (2) and the excellent work of Cummings and Stone (3) have covered very thoroughly various phases of the growth of the squash plant. The work which is reported in this paper was partially suggested by statements occuring in these publications.

Discussion of Problem

Yield is one of the important factors in the success or failure of the vegetable gardener. With a short season crop the date of planting may not greatly influence the yield. With a crop which requires a long growing season the importance of early planting cannot be over emphasized. If it can be shown that with certain crops each day's delay in planting results in a definite decrease in yield then effort can be made to direct cultural operations so that seed may be planted as early as possible.

Every variety of vegetables planted by the gardener should be efficient. In the industrial world machinery is constantly studied to determine whether it is efficient, or rather if it should be replaced. An inefficient variety of a vegetable is a variety that does not combine best quality, yield and appearance. Plant breeding methods are improving varieties. Existing varieties and strains are the tools of the plant breeder working to create more efficient varieties. Statistical study of the existing varieties presents the clue to the worker as to which to choose in order to get the possible recombination of characters desired.

Material and Methods

On June 2, rows of nine hills each were planted of strain 23 Hubbard and Kitchenette Hubbard, seed used representing selfed lines. On June 9, this planting was repeated and one row each of commercial seed of Quality, Delicious and Banana added. There were then seven rows 15 feet apart with nine hills 15 feet apart in each row, or 63 hills in all. After the first true leaves appeared the block was thinned to allow one plant per hill. Stakes were prepared

by cutting a lath in half, one end was pointed and the other smoothed and numbered with blue pencil.

TABLE I

Kitchenette Hubbard, Harvest September 20, Plant 8

Date	Stake Number	Progress	Date Inventory	Weight	Length	Diameter
August 6	84	213	August 15	6	21	19
August 6	85	Abort	August 15	....	..	..
August 8	132	271	August 23	5	19	17
August 8	133	Abort	August 23	....	..	..
August 10	241	523	August 23	5	19	17
August 13	397	524	August 23	4—5	18	17

Table I shows how data were recorded. The column, stake number, refers to number on the stake placed close to the pistillate blossom on date blossom opened. About once a week an inventory was made, at this time the stake at each pistillate flower that had aborted was pulled up and recorded under column headed progress. If a pistillate flower had set, the stake with blue number was pulled and replaced with new stake marked with red number. A paraffined tag with corresponding number was tied to the stem of the squash. Each squash that matured was weighed and its length and diameter measured. On the 63 plants 1995 pistillate blossoms were recorded, 394 of which set fruits.

Pistillate Blossoms: Totals and number fertilized.

1. To what extent do varieties or strains of squash differ in the total number of female blossoms produced per plant as well as in the percentage of those flowers which produce fruits?

The number of female blossoms produced during the season together with the number fertilized and matured is illustrated in *Table II*. The average number varies from 24.1 to 44.1 blossoms per plant for Quality and 23 Hubbard respectively. Compared with actual yields per plant these figures of number of blossoms are very high and it is a question if the plant could support as many should all the blossoms be successfully pollinated.

Unless there is a correlation between the number of blossoms and the number which produce fruits, a variety which has 50 per plant may not yield more than a variety which only has 25 blossoms per plant. Inspection of the table shows that the percentage of blossoms of Kitchenette which set was 41.4; of Quality, 22.9; Delicious, 22.8; 23 Hubbard, 7.8; and Banana, 5.5. Between varieties the ability to produce blossoms was not correlated with high yield. The variety producing the highest averaged only about one squash to every 20 female blossoms while the ratio of fruit matured to number of blossoms of Kitchenette was about one to 2.5. As between varieties the yield of squash per plant is dependent on the ability of the variety to successfully pollinate its blossoms as well as to produce a large number of flowers.

TABLE II

Pistillate Blossoms—Totals and Number Fertilized

Variety	Total Pistillate Blossoms	Average per Plant	C V	Blossoms Fertilized	Average per Plant	C V	Per cent Fertilized
23 Hubbard—Row 1	397	44.1	25.8	31	3.3	42.8	7.8
23 Hubbard—Row 2	259	28.7	40.6	18	2.0	74.5	6.9
Kitchenette—Row 1	285	31.6	27.0	118	13.3	21.8	41.4
Kitchenette—Row 2	217	24.1	31.7	95	10.5	41.6	43.7
Quality	240	26.6	28.2	55	6.1	30.4	22.9
Delicious	263	29.2	66.5	60	6.6	44.7	22.8
Banana	309	34.3	48.0	17	1.8	75.0	5.5

Rows marked one were planted June 2, others June 9. There were nine plants of each variety.

Within the varieties studied there was a positive correlation between the number of blossoms and number of fruits set on a given plant. The plants with the greatest number of female flowers tended to produce the greatest number of fruits.

Blossoming period and time of fertilization.

2. To what extent do varieties or strains differ in respect to the period in the growth of the plant during which pistillate blossoms are produced and during which fertilization of these blossoms occur? We know that with different varieties of squash there is a difference in the time that blossoms, fertilized blossoms, and mature specimens appear. What are the factors in relation to blossom habit which influence the earliness of varieties? It is probably true that the larger the squash the longer the time after fertilization required to reach maturity. This may not be directly proportional as the plants of one variety may be more vigorous and capable of great food production and consequently more growth per fruit per day. Two other factors governing earliness are time of blossom appearance and subsequent fertilization. The variety producing the earliest squash must produce pistillate blossoms early, must be sufficiently self sterile in order that the first pistillate blossoms that occur may be fertilized and then have a short growing period for complete development of the resulting squash.

In this study the date of opening of each female blossom was recorded together with the ultimate end of each blossom. *Table III* has been compiled to show varietal differences. It will be noted that all varieties were still producing pistillate flowers at the time record taking stopped, September 1. These late blossoms are on the smaller secondary branches and are apparently less receptive to fertilization. The earlier and larger the growth the larger the number of blossoms and fruits. Cummings and Stone (3) have shown a correlation in number of leaves and weight of fruits per vine. Observation indicates that within a variety there is correlation between earliness of blossoming, number of leaves and num-

TABLE III

Days from seed	Number of Pistillate Blossoms on Plants of Different Ages							Number Fertilized Blossoms Arranged According to Time of Opening						
	23 Hubbard	23 Hubbard	Kitchenette	Kitchenette	Quality	Delicious	Banana	23 Hubbard	23 Hubbard	Kitchenette	Kitchenette	Quality	Delicious	Banana
51-55	....	1	....	1	5	...	...	....	..	....	..	1	..	..
56-60	5	11	1	3	13	4	4	....	..	1	1	8	..	..
61-65	16	28	8	28	47	21	32	....	..	7	17	19	..	..
66-70	59	38	65	53	53	41	70	....	9	49	42	16	9	5
71-75	47	91	56	76	64	70	48	10	6	32	33	6	17	8
76-80	96	37	64	29	26	72	81	15	1	26	2	2	12	3
81-85	113	53	59	27	32	55	74	3	2	3	..	3	13	1
86-90	#61	...	#32	...	...	...	...	#3	..	#..	..	..	9	..
	397	259	285	217	240	263	309	31	18	118	95	55	60	17

Rows one and three planted June 2, others June 9.
Growing period seven days longer.

ber of flowers. Table III, with number of blossoms arranged in five day periods from seeding, shows that there was a difference between varieties in respect to earliness of appearance of female blossoms.

In Table III is also shown the number of fertilized blossoms arranged according to the time each opened. Not one of the first 80 blossoms of row one (23 Hubbard) were fertilized, while 57 out of the first 74 of Kitchenette, and 28 out of the first 65 of Quality, were fertilized. These varieties blossomed early and set fruit early. There is a difference in varieties with respect to the period in the growth of the plant during which female blossoms are produced and during which fertilization of these blossoms occurs. For a high yield it is important that the variety produce a large number of blossoms and that a large number of the early ones be fertilized.

Relation of time of blossom fertilization to weight of resulting squash.

3. To what extent does the time that the blossom is open and is fertilized influence the weight and shape of the resulting squash? Squash produced from any given planting will vary considerably. This variation occurs if the total yield is considered or even if the fruits of a single hill are compared. The variation in fruits on a plant is in shape, in appearance, but most noticeably in size. All who have grown squash have noted this variation, at harvest time there may be small immature specimens that have not had time to mature as well as some of marketable size. Among the marketable squash the weight of the largest and smallest often varies as much or more than 100 per cent. It is evident that this must be partly due to the continuous blossom habit of the plant. A blossom fertilized 50 days from seeding certainly should produce a larger squash than a blossom fertilized 25 days later. If this difference is large the time of seeding has a considerable influence in resulting yield.

TABLE IV

Days from Seed Blossom Opened and Average Weight in Pounds of Squash Pollinated Those Days

Days from Seed	Kitchenette	Kitchenette	23 Hubbard	Delicious	Quality
54	...	...	....	...	5.3
57	...	...	....	...	7.0
60	7.6	7.0	....	...	7.9
63	6.0	5.5	....	7.1	6.6
66	6.1	4.8	....	6.5	6.5
69	5.7	4.4	26.0	6.8	6.2
72	4.1	3.5	22.3	5.3	6.0
75	3.8	3.2	17.2	4.2	4.0
78	3.6	3.0	15.2	3	3.0
81	4.5	...	13	3.4	3.5

During 1923, squash was harvested 50 days after the first pistillate blossom appeared. The data for this paper were taken between July 30 and September 1, all squash harvested came from blossoms fertilized during this period. The weight of the squash produced decreased regularly as the number of days from seed on

which the blossoms were fertilized increased. The actual decreases in weight are shown in Table IV. The decrease in weight for every three day period amounted to 3.2 pounds for 23 Hubbard while for Kitchenette the decrease was one pound for every four days delay in opening of the blossom. Further evidence of the relation of date of blossoming and weight of resulting squash is furnished by the coefficients of correlation for four varieties. Coefficients of correlation for Kitchenette .917±.009, 23 Hubbard .726±.02, Delicious .539±.022, and Quality .310±.026. These indicate the dependence of weight on early blossoming. A possible explanation in the differences in correlation for the various varieties is the difference in the sterility of these varieties. A correlation table for 117 fruits is given in Table V for the Kitchenette Hubbard.

TABLE V

Correlation Between date Blossom Opened and Weight of Squash of Kitchenette Hubbard. Mean Weight of Squash, 5.01 ±.076; Standard Deviation, 1.22 ±.053; Coefficient of Correlation, .917 ±.009.

	Weight in Pounds								
Days from Seed	2	3	4	5	6	7	8	9	F
60-62	.	.	..	..	1	1	3	1	6
63-65	.	.	..	..	2	.	.	.	2
66-68	.	.	1	5	10	5	8	.	24
69-71	.	.	4	8	8	2	2	2	25
72-74	1	1	23	5	..	1	.	.	31
75-77	1	5	9	4	..	.	.	.	19
78-80	2	2	3	..	..	.	.	.	7
81-83	.	1	..	1	1	.	.	.	3
F	4	9	40	23	22	9	8	2	117

SUMMARY

A record was kept of the date of the appearance of each pistillate blossom and weight, length and width dimensions taken for each squash resulting from the fertilization of these blossoms. These data were taken on the individual plant basis.

1. Varieties differed in the number of pistillate blossoms produced per plant from 24.1 to 34.3.
2. There was wide variation between varieties in the percentage of pistillate blossoms which produce mature specimens, it varied from 5.5 in Banana to 43.7 per cent in Kitchenette.
3. Between varieties the ability to produce blossoms and set fruits appeared to be independent.
4. Within a variety there was a correlation between number of blossoms and number of squash produced.
5. The appearance of pistillate flowers occurs at varying lengths of time from date of seed planting according to the variety.
6. There was evidently wide variation in the sterility of different varieties. Some (Kitchenette, Quality) set a large per cent of early blossoms, other varieties (23 Hubbard) abort a large number of early blossoms, while with others (Delicious) the per cent of blossoms which set remains about the same throughout the season.

7. There is a direct correlation between weight of resulting squash and number of days from seed on which blossom opened.

8. In varieties producing large squash (15-30 pounds) a decrease in weight was found which amounted to one pound per day delay in fertilization of the blossom.

9. Yield among other factors depends on the ability of a variety to produce a large number of blossoms, to produce these early, to fertilize a larger per cent of the total blossoms and to fertilize those which appear early in the growing season.

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GREAT PLAINS SECTION* OF THE A. S. H. S.

THE annual meeting of the Great Plains Section of the Society was held in Wisconsin on July 10, 11 and 12, 1923, beginning at Grand Rapids and ending at Sturgeon Bay.

The first point of interest visited was the cranberry bogs of which there are several hundred acres a few miles out from Grand Rapids. In age they vary from one year to 45 years. This is a successful enterprise and even the oldest bogs, where kept free of weeds, are in vigorous condition. There are two methods of gathering the berries, wet and dry. The wet method consists in flooding the bogs so the berries all float and can be easily gathered with a cranberry scoop. Wet and dry picked berries seem to keep equally well, but the market tends to favor the dry picked fruit.

Near Oshkosh the Wealthy apple orchard was visited in which Professor R. H. Roberts is conducting his tree pruning and nitrogen fertilizer experiments. By means of charts and the trees themselves, Prof. Roberts explained the pruning and nitrogen responses which the trees are showing.

Visits were made to a couple of spray ring orchards and a farm home landscape demonstration. The orchards showed good results of the pruning and spraying given. The landscape demonstration was of especial interest. The lawn and shrubs were in fine condition, but a long border of brilliant hollyhocks was the center of attraction. Some of the neighbors have improved their yards as a result of this demonstration. From here an auto trip was made to Sturgeon Bay. That evening a meeting was held at the Country Club where the members stayed. Professor A. F. Yeager read a paper on The Bush Form Fruit Tree which is included in this annual report.

Prof. F. W. Broderick gave a very comprehensive paper on Numbering Plant Breeding Material. He cited the methods used by many plant breeders in numbering their seedlings. Prof. Broderick felt that more study should be given this subject before publishing it in the annual report.

The next day was spent in the sour cherry district of Door County. There are 5,000 acres of sour cherries here and the cherry harvest was in full swing. Several thousand pickers were being employed. There were great camps where hundreds of pickers were quartered. Most of the camps had military discipline and everything was so well organized that the various operations of cherry picking, packing, shipping, or delivering the fruit to the canning factory, moved along like clock work. Two varieties, Early Richmond and Montmorency are grown exclusively.

Miles of territory were covered and many orchards were visited to get a grasp of the immensity of the sour cherry industry. In these orchards Professor R. H. Roberts worked out and demon-

*The local Secretary of this Section did not send in a report of this field trip so Secretary Close who was on the trip prepared this brief account of it.

strated his method of sour cherry tree pruning. This is one of the outstanding pieces of fruit demonstration work and seems to have been adopted by practically all of the cherry growers there. The idea is to thin out crowding branches and cut back leaders so that an annual new growth of about a foot is made. There are lateral buds on the new shoots, which will stand lower winter temperatures than spur buds and these lateral buds practically insure a crop each year if fertilizing and spraying directions are followed to keep the trees healthy and growing. Formerly these trees were old and unprofitable at about 17 years from planting. Now their span of life is considered to be doubled. The older tall trees have been, or are being, headed back and new tops are being grown.

Fertilizing is simple, about three pounds of nitrate of soda early in the spring per medium sized bearing tree. Spraying as per the Experiment Station recommendation is keeping the foliage healthy and vigorous.

The Bush Form Fruit Tree

By A. F. YEAGER, *Experiment Station, Fargo, N. D.*

IN United States Department of Agriculture Circular No. 58 published in 1919, Max Pfaender, then Horticulturist at the Northern Great Plains Field Station, Mandan, N. D., recommends the growing of fruit trees without trunks as a means of preventing sunscald. His line of thought was reasonable so an experiment was started at the North Dakota Experiment Station, to determine the value of the idea. In the spring of 1920, two blocks of Hibernal apple were planted. Each lot consisted of 10 trees. One of these was composed of trees which had been permitted to branch at the ground, the other of trees whose top had been formed at about two feet from the ground. Minnesota seedlings were the stock in each case and an inspection of the trees showed them to be excellent trees closely resembling each other except for the length of trunk. Light pruning and a clean cultivation and cover crop soil management system, have been followed in each case. Careful records of the performance of these trees has since been kept. While there has been no sunscald on any of these trees to date, there are decided enough differences to call for comment.

During the first season one of the standard trees failed to survive. All the other trees of both blocks made some growth. There was no apparent difference between the blocks and because the growth was negligible it was not measured.

At the end of the second season all terminal growth made that season was measured on each tree. The results showed that:

Standard trees made an average length growth of 60 inches.

Bush type trees made an average length growth of 125 inches.

At the end of the third season the terminals were again measured showing the following results:

Standard trees made an average length growth of 145 inches.
Bush type trees made an average length growth of 346 inches.

This spring at the beginning of the fourth season the first blossoms appeared. A tabulation of the amount of bloom shows:

	Trees with much bloom	*Trees with some bloom*	*Trees with no bloom*
Standard trees	1	3	5
Bush type trees	5	4	1

During the present season it is evident that the bush type trees are again producing longer terminal and spur growths. Since the number and vigor of growing tips per tree determines in large measure the possible set of fruit buds for the following season, a count of the number of terminals per tree was made June 25. It shows:

Standard trees have an average of 121 terminals per tree.
Bush type trees have an average of 235 terminals per tree.

For the more moderate parts of the country early bearing is not of such great importance as it is where test winters recur rather frequently. It would be a liberal estimate to say that an apple tree in North Dakota under the usual conditions and with reasonable care lives 12 years. Speeding up the time of fruitfulness is then of great importance. Growing a bush type tree seems to do that here when compared to standard trees, just as Howe finds that in New York what we term standard trees bear a year earlier than long trunk trees. At the same time it is more than probable as Pfaender says, that a bush tree will outlive a standard for it has been my observation that the two great causes for the early death of apple trees in North Dakota are sunscald and fireblight. The trunk is decidedly a weak point.

Sandcherry hybrids form a class of fruit which is most dependable in the Northern Great Plains area. Nevertheless many failures with them have been found. Possibly the following will explain the trouble to some extent. These trees as other fruit trees are grown by nurserymen with a two foot trunk and are sold to the farmer as two year old trees. At the North Dakota Experiment Station we planted that type of tree in our variety plantation. In examining these at various times I have been struck repeatedly by the superior vigor of the lower branches, or sprouts, which came out of the trunk near the ground, and have noted the frequent death of limbs forming the original head. No effort has been made to favor either the lower or higher branches, yet I found upon examining the trees this spring that out of 31 sandcherry hybrid trees set in 1919 and '20, but seven have any of the original top alive. In other words, they have formed a top down at the ground level. On these vigorous shoots we have this year our first heavy fruit crop. With these fruits, two years were lost because of the long trunk. One exception should be made in the sandcherry hybrids. Among the seven trees mentioned above as retaining part of their

original top were four compass cherry trees which seemed perfectly at home on the trunk originally given them.

No comparisons were made on plum trees. They seem to thrive on standard trunks, though perhaps even they might prefer one more abbreviated.

As a disadvantage of the bush type the difficulty of cultivating might be mentioned. But where it is a choice between difficult cultivating and fruit, and easy cultivating and no fruit, the choice is quickly made.

As special advantages of the bush form of tree we might mention the smaller danger of breaking down where exposed to the strong winds of summer. With plums that is very important. Then too we have had several trees escape death from mice, or rabbit girdling, because the rodent would peel only the outside portions leaving enough bark to permit recovery on the inside of the branches. In exposed places these low down trees will check the wind and hold leaves and snow much better than will standard trees. Data taken during the winter of 1921-22, show that one foot of snow prevented two feet of frost penetration with a consequent saving of 25 per cent of the apple trees which were killed where the ground was bare.

Much as he would like to grow the shade tree type of orchard it is evident that it is to the interest of the fruit lover of the Northern Great Plains to come down to earth with his tree tops.

NORTHEASTERN SECTION OF THE A. S. H. S.

By S. P. Hollister, *Local Secretary, Agricultural College, Storrs, Conn.*

THE first meeting of the Northeastern Section of the Society was held at the Agricultural College, Amherst, Massachusetts, on July 26, 1923.

Program of Morning Session

Supervised Student Orchard Experience—G. F. Potter.

Lecture Methods vs. Textbook—S. P. Hollister.

The Coordination of Theoretical Instruction with Practical Experience—W. Paddock.

Horticultural Manufacturing as a College Course—W. F. Robertson.

Program of Afternoon Session

Business and Reports of Committees:

An Excursion over the Pomology Department.

Experimental Demonstrations vs. Demonstrational Experiments—S. B. Haskell and H. P. Sweetser.

Large Scale Experiments with General Records vs. Small Scale Experiments with many Exact Records—J. K. Shaw.

Professor F. C. Sears presided at the meetings and the following members were present:

H. P. Sweetser, ...Maine
G. F. Potter, ...New Hampshire
S. W. Wentworth, ...New Hampshire
H. A. Rollins, ...New Hampshire
H. V. Marsh, ...Rhode Island
S. P. Hollister, ...Connecticut
J. S. Bailey, ...Massachusetts
W. R. Cole, ...Massachusetts
B. D. Drain, ...Massachusetts
W. K. French, ...Massachusetts
C. P. Jones, ...Massachusetts
S. B. Haskell, ...Massachusetts
O. C. Roberts, ...Massachusetts
W. R. Robertson, ...Massachusetts
G. J. Raleigh, ...Massachusetts
F. C. Sears, ...Massachusetts
J. K. Shaw, ...Massachusetts
Chester Spofford, ...Massachusetts
R. A. Van Meter, ...Massachusetts
H. E. Wilson, ...Massachusetts
G. L. Slate, ...New York
H. B. Tukey, ...New York
W. Paddock, ...Ohio

The following points were brought out by Professor Hollister's discussion:

1. There is no one textbook suitable for all college classes, conditions vary so in each institution.
2. Lectures must be supplemented by textbooks and references.
3. Textbooks must be supplemented by lectures and references.

Professor Paddock briefly outlined a method he used, which consists of assigning one or more topics to each student to discuss in class at some future date. He stated that a broad horticultural course is one of the best educational fundations for life work. In discussing class work, he felt that outlines should be furnished students for all field trips.

Some points brought out by Professor Potter were as follows:

1. Learn by doing.
2. Student having done something, can then be told more about the subject.
3. Expectation of doing something helps in keeping up the interest.

The point which Professor Potter dwelt upon was, that a student gains 60 per cent more knowledge if he has actually had experience in the work. He illustrated point two as follows:—One of the men who had taken a course in spraying had not been responsible for a power outfit until after leaving college, and when he came back for information which he stated had never been given

in class, Professor Potter was able to turn to his notes and show that the student had been given the information, but as he had never handled a power outfit previous to the time the information was given, he was able to comprehend but 40 per cent of the subject.

Professor Potter also discussed the experiment which he is going to start next year, namely of having the men who are specializing in pomology spend the spring term of their junior year in actual work and receive college credits for this work. He said that at first practically all the faculty were against the proposition, but gradually they were willing to allow the experiment to be tried.

Mr. Robertson gave a very interesting discussion and outlined the work which would naturally be considered in a college course of Horticultural Manufacturing.

Director Haskell started the discussion regarding experimental work, and briefly outlined some of the lines of work which are being carried on at Amherst. Professor Sweetser mentioned the great responsibility which rests upon the experiment stations and that good judgment must be exercised in presenting experimental evidence, or results, to the public. He stated that some of the fruit growers in Maine were purchasing root grafts and were growing their own trees, he felt that home grown trees could be produced for 15 cents each.

Dr. Shaw in his discussion of experimental pomological work, contrasted the large field experiment with the laboratory, or small type problem, and he emphasized the point that both have a place, that we cannot do away with either, and when opportunity exists each should be used to advance the other. He ended his remarks by stating that while many held the idea that the field experiment was a thing of the past and should be discarded, he felt it still has and will have for some time an important place in pomological research.

On the field trip some of the points mentioned by Dr. Shaw were illustrated. The orchard of trees on known stocks was very interesting, McIntosh and Siberian crab stocks were two of the varieties producing the strongest trees.—Tolman on Tolman was very weak.

Motion: It was moved and carried that the group be known as the Northeastern Section of the American Society for Horticultural Science, and that the local secretary so notify Secretary C. P. Close.

SOUTHEASTERN SECTION OF THE A. S. H. S.*

By W. R. Beattie, *United States Department of Agriculture, Washington, D. C.*

THE Southeastern Section of the American Society for Horticultural Science met in conjunction with the meeting of the Southern Agricultural Workers at Birmingham, Alabama, January 10 and 11, 1924. There were present at this meeting representatives from the states of North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana and Kentucky. In addition to the presentation of papers very excellent reports covering the progress of work in the various Southeastern States were presented. Among the papers presented were the following:

Recent Development in Grape Growing in Florida—E. L. Lord, Gainesville, Florida.

Observations on the Hardiness in Plums—A. J. Olney, Lexington, Kentucky.

The Pineapple Pear—H. P. Stuckey, Experiment, Georgia.

Pecan Propagation—C. S. Isbell, Auburn, Alabama.

Blueberries in Western Florida—C. B. James, Montgomery, Alabama.

Improved Irish Potato Seed—William Stuart, United States Department of Agriculture, Washington, D. C.

The Home Orchard and Home Garden—W. R. Beattie, United States Department of Agriculture, Washington, D. C.

The paper by Professor Stuckey on the Pineapple pear was of particular interest from the standpoint of indicating the climatic conditions under which this pear will thrive, also its value as a commercial pear for the section of the Gulf and Atlantic Coast regions where Keiffer and other similar pears are subject to blight.

The paper by Professor Olney was the result of observations made upon a large number of plum varieties following the freeze during the blooming period last spring.

The paper presented by Mr. James, gave a splendid account of the origin and expansion of the blueberry industry in western Florida. This industry is based upon the cultivation of selected types of the native wild blueberries.

The reports on horticultural work made by representatives from the various states of the southeastern group showed conclusively that the plan for the correlation of horticultural work between the various states as made at the meeting in 1920, is being closely adhered to, and that the various problems both of investigational and extension work in horticulture are now being handled as a regional matter rather than as state problems.

*Although this meeting was held in 1924, it is mentioned in the 1923 report because it is live matter now, but will be too old to be of interest if held for the 1924 report. None of the papers read at this meeting have been sent to the Secretary for printing in this report.

It was urged that in both investigational and extension work more attention be given the matter of long period programs.

The meetings of the horticultural section which were confined to two afternoons were of great interest, but would have been improved by a more extended period of time for the consideration of several topics.

Items of Business

Amendment to Constitution

At the Boston meeting an amendment to the constitution was offered changing the first line of Article V to read "a Vice-President" instead of "three Vice-Presidents." This amendment was adopted.

Amendment Offered to Change By-Laws

Professor W. H. Alderman offered an amendment to Section 5 of the By-Laws, changing the last word "seven" of the first line to "three." This amendment will be voted on at the 1924 annual meeting. If adopted, the number of members on the program committee will be changed from seven to three.

Membership Committee Discontinued

The membership committee was discontinued and the Assistant Secretary was requested to assume the former duties of this committee.

Propose Sectional Meetings in Washington

Upon motion the Program Committee was instructed to use its discretion as to whether or not it will be desirable to provide for sectional meetings in 1924.

Abstracts of Papers for Program Committee

A motion was adopted providing that each author presenting the title of an address for the 1924 program, shall, by November 1, submit to the chairman of the program committee an abstract not exceeding 100 words. of his address, and that the Secretary shall have these abstracts either printed or mimeographed for use at the Washington meeting.

Election of Officers

In making its report the nominating committee submitted the names of M. J. Dorsey and L. Greene as candidates for president. These names were balloted upon and M. J. Dorsey receiving the majority was declared candidate for president. A motion was then passed instructing the secretary to cast the vote of the Society in favor of the candidates nominated by the committee. The names of officers elected and the committees appointed for 1924 are given on Page four of this report.

Roosevelt-Sequoia National Park

The following resolution was offered by Dr. W. L. Howard of California, and was unanimously adopted by the Society.

WHEREAS, The Sequoia National Park, situated on the western slope of the Sierra Nevada Mountains in California, contains some of the best remaining groves of the fast disappearing Giant Big Trees (Sequoia gigantea), as well as some of the most picturesque scenery to be found in the United States, all of which are now a part of the Public Domain; and

WHEREAS, The friends of conservation desire to preserve these monuments and natural resources, consisting of timber and water power for the good of all the people; and

WHEREAS, Certain interests are seeking not only to exploit the above mentioned resources, but to actually reduce the limits of the present Sequoia Park, so as to abandon the famous Garfield Grove of Big Trees:

THEREFORE, BE IT

RESOLVED, That we favor the plan to enlarge the present Sequoia National Park, lying between the Kings and Kern rivers, to agree with the boundaries of the proposed Roosevelt-Sequoia National Park, and disapprove and condemn the movement to restrict the size of the present Park as provided for under the so-called Barbour Bill which was discussed in the last Congress, but which failed of passage.

WILL NOT AFFILIATE WITH AMERICAN HORTICULTURAL SOCIETY

With respect to the invitation to affiliate with the National Horticultural Society, the following motion offered by Prof. M. A. Blake was unanimously adopted:—

The American Society for Horticultural Science is in full sympathy with every phase of progress in horticultural development throughout the country, including the success of such organizations as the American Horticultural Society, but it is the sense of this meeting that we can best serve horticulture in general my remaining as an independent organization, and confining our official efforts to our present field of activities.

REPORT OF SPECIAL COMMITTEE ON PROFESSOR J. C. BLAIR'S ADDRESS

Your Committee appointed to consider matters growing out of the general discussion of yesterday afternoon, begs to report as follows.

1. We recommend that no attempt be made to hold a summer meeting of the A. S. H. S. in 1924; but we do recommend that such a meeting be held during the summer of 1925.
2. That a Committee be appointed at this time having in charge arrangements for such a meeting.
3. That at the next regular meeting of this Society, the time necessary to be devoted to discussions along the lines suggested by Prof. Blair's address, particularly the following items, be arranged for with the program committee by a special committee of five to be appointed.

(a) Outlines of laboratory work for certain Horticultural Courses.

(b) The best outline for a course in Freshman Horticulture, (i. e., what should constitute a beginning course in Horticulture.)

(c) Outline of course or courses for Sophomore Horticulture.

(d) Should we teach science or practice, or both, and if so, how far shall we go?

(e) What are we going to do with the horticultural students who have had training in horticulture through the vocational agricultural courses in high schools or colleges?

(f) Outlines for a course in experimental horticulture.

(g) Methods of interpreting results of horticultural experiments.

(h) Advantages and disadvantages of organization and standardization or unification of effort in horticultural research.

J. C. Blair
W. Paddock
L. Greene
M. J. Dorsey
J. H. Gourley
H. C. Thompson
M. A. Blake
W. H. Alderman
Committee.

Report of the Committee on Resolutions

Resolved, That the members of the American Society for Horticultural Science extend to the University of Cincinnati and the various local committees, our appreciation of the very complete arrangements they have made for the success of our meetings. Apparently no detail has been overlooked which would afford either comfort, or convenience.

Also be it further resolved, That we extend to our officers and committees our appreciation for their efforts in making this meeting and our Society a success. Particularly is our Secretary to be commended for the business-like manner in which the details of his office are handled.

W. Paddock,
C. A. McCue,
E. F. Palmer,
Committee.

Dinner and Social Evening

THE dinner was a most pleasing affair and was enjoyed by eighty-one people of which all were members except half a dozen guests. This was the largest attendance we have ever had at a Society dinner. There were four charter members present, William Stuart, Wendell Paddock, J. C. Blair and C. P. Close.

A pleasant surprise was a Delicious or Golden Delicious apple at each plate, these were presented by Stark Brothers of Louisiana, Missouri.

After the dinner the social feature began with a self introduction stunt in which each member in turn stood up and stated his name, his institution, and line of work. The visitors introduced themselves in the same way.

The President of the American Pomological Society, Mr. Paul C. Stark, had asked for an opportunity to speak on the outlook and plans for a Greater American Pomological Society and was called on after the introduction act. He told of the growth of membership through cooperation with the state horticultural societies, the very extended auto tour planned through the fruit districts of 17 states in the summer of 1924, and other points of interest connected with the American Pomological Society.

The social hour then took on the aspect of a business meeting. Prof. R. E. Marshall reported on the present status of biological abstracts, and stated that those in charge of the finances and work are hopeful of having a satisfactory arrangement made to take care of the editorial and overhead expenses.

The Society suggested to the Board of Botanical Abstracts the name of Prof. A. J. Heinicke for editor of the horticultural section of Botanical Abstracts.

A resolution was adopted expressing the sympathy of our membership to Prof. W. T. Macoun in his recent bereavement over the loss of his wife.

Dr. W. A. Orton discussed the newly organized American Horticultural Society and asked the A. S. H. S. to affiliate with it. No action was taken at the time, but during the afternoon session of the next day, the matter was presented, and by a unanimous vote the invitation to affiliate was not accepted. (See under Items of Business).

A resolution pertaining to the proposed Roosevelt Sequoia National Park was drafted by Dr. W. L. Howard of California and sent to the Secretary. This resolution was presented and adopted. (The resolution appears under Items of Business).

Following the address of Prof. J. C. Blair on The Need of a Nation-wide Conference in Horticultural Teaching, Research, and Extension, on Thursday afternoon, a committee was appointed to consider the address and make a report during the social evening. The committee report as finally adopted is printed under Items of Business. One change made in adopting this report was in the

length of time to be given to the topics it recommended for the program of the Washington meeting. A full day was provided for originally.

The report of this committee brought out the most spirited and long drawn out discussion that the members of the Society have indulged in at any social evening. Since paragraphs one and two of the report deal with a proposed summer meeting in 1925, and paragraph three deals with the 1924 annual meeting in Washington, the report was divided and a motion was carried to adopt paragraphs one and two. Then paragraph three came up for adoption. The bone of contention was the setting aside of a whole day at Washington for the eight topics listed in this paragraph. A motion finally prevailed that a committee of five be appointed to study the whole question of courses, organization, laboratory work, etc., and report in full at the Washington meeting, and to arrange with the program committee for the necessary time for presenting and discussing the topics in paragraph three. The following members were appointed on this committee: J. C. Blair, W. Paddock, V. R. Gardner, H. C. Thompson and W. H. Alderman.

Obituary

THEODORE A. FARRAND

MR. T. A. Farrand, Extension Specialist in Pomology at the Michigan Agricultural College and Secretary of the Michigan State Horticultural Society, died in a Detroit hospital on December 12, 1923.

Mr. Farrand was born near Dearborn, Michigan. Denied the privileges even of a high school education, he was a self-made man. The late T. T. Lyon saw in him a love for, and a keen interest in, fruits, and engaged him as an assistant at the South Haven Experiment Station. Mr. Farrand was later appointed as Superintendent of that Experiment Station, serving in that capacity from April, 1902 to January, 1906. He then purchased a fruit farm at Eaton Rapids, Michigan, where he has since lived, and in addition to the orchard he established a small greenhouse business. Shortly after taking up his residence in Eaton Rapids he leased several orchards in southern Michigan and in the northwestern part of Missouri.

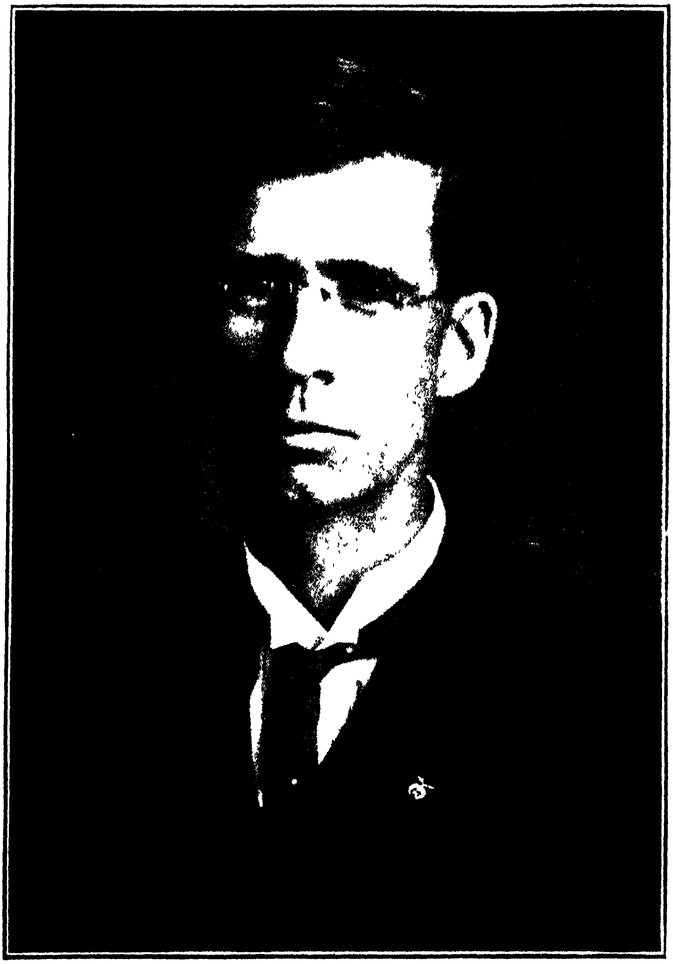
He was again called into public life, first as a farmers' institute lecturer, then as county agent of Van Buren County, one of the largest fruit producing counties of Michigan. During the world war he served his home county in this capacity. Because of his peculiar ability to maintain contact between the College and the fruit growers of Michigan, he was selected to serve in the dual capacity of Secretary of the Michigan State Horticultural Society and Extension Specialist in Pomology in January, 1920.

Though Mr. Farrand did practically no writing, other than the reports of the South Haven Experiment Station, through his ability to inspire in personal visit and from the lecture platform, his influence was very great. It was in this manner that he came in contact with practically every fruit grower in Michigan. Fruit growers liked his enthusiasm, straight-forward manner, and the fact that he never lost sight of practicability of orchard practices. Further than this, I cannot do better than quote a paragraph from an editorial in The Michigan Farmer.

"But few are better known in Michigan than T. A. Farrand. His message of better horticulture and his abounding enthusiasm made him lasting friends everywhere. But what will remain in the memory and hearts of those who knew him, more than anything else, was the gospel of optimism which he preached through example. Through all the trials of life, his smile and his laughter were ever present. His enthusiasm and his never say die attitude have made him an outstanding figure among those who have worked for better rural Michigan."

ROY E. MARSHALL.

THEODORE A. FARRAND



PROFESSOR LEROY CADY

PROFESSOR LEROY CADY

The Minnesota Horticulturist of November, 1923, contains a most worthy and glowing tribute to the late Professor LeRoy Cady prepared by Professor R. S. Mackintosh. Extracts of this tribute are given below.

"His life work came to a close on the last day of the state fair amid the flowers and plants he so dearly loved. For years he had labored unceasingly for the upbuilding of the floral exhibits in the Horticultural Department of the Fair. The writer saw him on his last trip about the building. At that time he was as jovial as usual and did not appear to be in pain. He was stricken a short time later and on the advice of his physician was taken at once to a hospital in St. Paul, where an operation was performed that evening. He recovered from the operation and at first seemed to be holding his own but on Monday his condition was not so good, and early Wednesday morning, September 12, he quietly passed to the great beyond. Although his condition was serious, he did not lose faith, but believed that he would survive. We mourn the loss of a true friend and tireless worker in our society, state and community.

"He was born on the farm of his parents, George L. and Agnes P. Cady, at Buffalo, Wright County, January 9, 1879.

"In the fall of 1897 he entered the School of Agriculture of the University of Minnesota and graduated in 1900. He leaned toward horticultural work and spent his summers working in that division under the late Professor Samuel B. Green. A few years later he took charge of the gardens and grounds at the State School, at Owatonna. In 1903 Professor Samuel Green invited him to return to the Division of Horticulture to become his assistant in teaching the large classes in the school. He soon entered the College of Agriculture and graduated in 1907 with the degree of B. S. in Agriculture. The year previous he was given the rank of instructor. In 1910, after the untimely death of Professor Green, he was made assistant professor, and in 1911 made associate professor in charge of the horticultural work. In 1913 the work of the division was divided and he took charge of the section of floriculture and landscape gardening. Part of his duties consisted in caring for the grounds and we all know how well kept and how beautiful they have been at all times. He was in the employ of the University for more than twenty years when the Department of Agriculture was expanding from a minor position to one of great importance.

"He was the author of several practical bulletins dealing with farm gardening, small fruits and attractive farmsteads."

He assisted in preparing "Landscape Gardening in Minneapolis" and "Popular Fruit Growing." Titles of other subjects upon which he wrote are: "A Summer in a Greenhouse and Flower Garden;" "Wisconsin Trial Orchards;" "Purpose and Scope of Cross Pollination;" "Pollination of Orchard Fruits;" "Grafting;" "Shrubs and Trees for Ornament;" and "Hedges and Hedge Plants." For years he edited the horticultural page in the Northwest Farmstead.

Lecoq Herc Nelson

Lecoq Herc Nelson was born at Nancey, Kentucky, on January 21, 1893. He received his early educational training in the schools of Russel Springs, Nancey and Somerset, in Kentucky. At the age of 19 he entered the University of Kentucky and graduated with honors in 1916. He taught in the high school in Centerville, Maryland, until in 1917 he volunteered for service in the officers training camp at Camp Taylor, Kentucky. He served in the World War as second lieutenant in field artillery and was honorably discharged from the service on December 11, 1918.

Soon after returning to civil life he joined the horticultural staff of the State Department of Agriculture, North Carolina, at Raleigh, and spent four years as Assistant Horticulturist in fruit work. He rendered the state efficient service and was highly esteemed by his associates and made many warm friends throughout the State.

Early in January, 1923, Mr. Nelson had a very severe case of influenza which developed into pneumonia and he passed away on January 11. He was a member of the Raleigh Post of the American Legion and he was buried with Legion honors at Raleigh.

LECOQ HERC NELSON

Membership Roll for 1923 *

ADRIANCE, G. W. ......A. & M. College of Texas, College Station, Texas
ALDERMAN, W. H. .....University Farm, St. Paul, Minn.
ALLEN, F. W. ....University Farm, Davis, Calif.
ANDERSON, O. G. ......Purdue University, Lafayette, Ind.
ANTHONY, R. D. ......Experiment Station, State College, Pa.
AUCHTER, E. C. ....University of Maryland, College Park, Md.
AXT, R. W. ....University of Illinois, Urbana, Ill.

BAILEY, J. S. ....Agricultural College, Amherst, Mass.
BAILEY, L. H. ....Ithaca, N. Y.
BAIRD, W. P. ....Northern Great Plains Field Station, Mandan, N. D.
BALCH, W. B. ....Agricultural College, Manhattan, Kans.
BALLARD, W. R. ....University of Maryland, College Park, Md.
BARNETT, R. J. ....Agricultural College, Manhattan, Kans.
BARRON, LEONARD ......Garden City, N. Y.
BARSS, A. F. ....University of British Columbia, Vancouver, B. C.
BATCHELOR, L. D. ......Citrus Experiment Station, Riverside, Calif.
BEACH, F. H. ....Ohio State University, Columbus, Ohio.
BEATTIE, J. H. ....U. S. Dept. Agr., Washington, D. C.
BEATTIE, W. R. ....U. S. Dept. Agr., Washington, D. C.
BEAUMONT, J. H. ......University Farm, St. Paul, Minn.
BEISIEGEL, H. B. ....Agricultural College, East Lansing, Mich.
BENNETT, J. P. ....University of California, Berkeley, Calif.
BEYSCHLAG, F. G. .....U. S. Dept. Agr., Washington, D. C.
BIOLETTA, F. T. ....University of California, Berkeley, Calif.
BLAIR, J. C. ....University of Illinois, Urbana, Ill.
BLAIR, W. S. ....Experiment Station, Kentville, Nova Scotia.
BLAKE, M. A. ....Experiment Station, New Brunswick, N. J.
BOSWELL, V. R. ....University of Maryland, College Park, Md.
BOUQUET, A. G. B. ....Agricultural College, Corvallis, Ore.
BRADFORD, F. C. ....Agricultural College, East Lansing, Mich.
BREGGER, J. T. ....Louisiana, Mo.
BRIERLEY, W. G. ....University Farm, St. Paul, Minn.
BROCK, W. S. ....University of Illinois, Urbana, Ill.
BROWN, H. D. ....Purdue University, Lafayette, Ind.
BROWN, W. S. ....Agricultural College, Corvallis, Ore.
BUCK, F. E. ....University of British Columbia, Vancouver, B. C.
BUNTING, T. G. ....Macdonald College, Macdonald College, Quebec, Can.
BURKHOLDER, C. L. ....Purdue University, Lafayette, Ind.
BURROWS, A. M. ....University of Missouri, Columbia, Mo.
BUSHNELL, J. W. ......Experiment Station, Wooster, Ohio.
BURNSIDE, B. L. ....University of Maryland, College Park, Md.

CALDWELL, J. S. ....U. S. Dept. Agr., Washington, D. C.
CAMERON, S. H. ....University of California, Berkeley, Calif.
CARDINELL, H. A. ......Agricultural College, East Lansing, Mich.
CARPENTER, C. C. ......Syracuse University, Syracuse, N. Y.
CARRICK, D. B. ....Cornell University, Ithaca, N. Y.
CHANDLER, W. H. .....University of California, Berkeley, Calif.
CHENOWETH, W. W. ...Agricultural College, Amherst, Mass.
CLARK, C. F. ....U. S. Dept. Agr., Washington, D. C.
CLARK, J. H. ....Experiment Station, New Brunswick, N. J.
CLOSE, C. P. ....U. S. Dept. Agr., Washington, D. C.
COCHRAN, G. W. ......Purdue University Lafayette, Ind.
COIT, J. E. ....1880 Linda Vista Ave., Pasadena, Calif.
COLBY, A. S. ....University of Illinois, Urbana, Ill.
COLE, W. R. ....Agricultural College, Amherst, Mass.
CONDIT, I. J. ....California Peach and Fig Growers Association, Fresno, Calif.
CONNORS, C. H. ....Experiment Station, New Brunswick, N. J.
COOPER, J. R. ....University of Arkansas, Fayetteville, Arkansas.
CORBETT, L. C. ....U. S. Dept. Agr., Washington, D. C.

* See obituary for deceased members

CRANDALL, C. S. ......University of Illinois, Urbana, Ill.
CRANE, H. L. ....University of West Virginia, Morgantown, W. Va.
CRIST, J. W. ....Agricultural College, Corvallis, Ore.
CROSS, F. B. ....Oklahoma A. & M. College, Stillwater, Okla.
CROW, J. W. ....Simcoe, Ontario, Canada.
CRUESS, W. V. ....University of California, Berkeley, Calif.
CRUICKSHANK, R. B. ..792 West 7th Avenue, Columbus, Ohio.
CULLINAN, F. P. ......Purdue University Lafayette, Ind.
CUMMINGS, M. B. ......Experiment Station, Burlington, Vt.

DALY, M. ....Central Experimental Farm, Ottawa, Canada.
DANIELS, F. P. ....University Farm, St. Paul, Minn.
DARROW, G. M. ....U. S. Dept. Agr., Washington, D. C.
DARROW, W. H. ....Agricultural College, Storrs, Conn.
DAVIS, M. B. ....Dominion Experimental Farm, Ottawa, Canada.
DEARING, CHARLES .....Willard, N. C.
DETJEN, L. R. ....University of Delaware, Newark, Del.
DICKSON, G. H. ....Vineland Station, Ontario, Can.
DIKEMAN, R. C. ......School of Agriculture for Women, Ambler, Pa.
DORNER, H. B. ....University of Illinois, Urbana, Ill.
DORSEY, M. J. ....West Virginia University, Morgantown, W. Va.
DRAIN, B. D. ....Massachusetts Agricultural College, Amherst, Mass.
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EDMINSTER, A. F. ......Spring Brook Farm, East Freetown, Mass.
EUSTACE, H. J. ....Curtis Publishing Co., San Francisco, Calif.

FAGAN, F. N. ....Experiment Station, State College, Pa.
FAGER, G. E. ....University of Illinois, Urbana, Ill.
FARLEY, A. J. ....Rutgers College, New Brunswick, N. J.
FAROUT, F. W. ....Missouri Fruit Station, Mountain Grove, Mo.
FISHER, D. F. ....Wenatchee, Washington.
FLOYD, W. L. ....University of Florida, Gainesville, Fla.
FRENCH, A. P. ....Agricultural College, Amherst, Mass.
FRENCH, W. K. ....Agricultural College, Amherst, Mass.
FROST, H. B. ....Citrus Experiment Station, Riverside, Calif.

GARDNER, A. K. ....University of Maine, Orono, Me.
GARDNER, J. S. ....University of Kentucky, Lexington, Ky.
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GARDNER, M. W. ....Purdue University Lafayette, Ind.
GARDNER, V. R. ....Agricultural College, East Lansing, Mich.
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GEISE, F. W. ....University of Maryland, College Park, Md.
GLADWIN, F. E. ....Experiment Station, Fredonia, N. Y.
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GOULD, H. P. ....U. S. Dept. Agr., Washington, D. C.
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GREENE, L. ....Purdue University Lafayette, Ind.
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HARRIS, R. D. ....Agricultural College, Amherst, Mass.
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HARVEY, H. W. ....College of Agriculture, Athens, Ga.
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HENDRICKSON, A. H. ...Decidious Fruit Station, Mountain View, Calif.
HEPLER, J. R. ....Agricultural College, Durham, N. H.
HERRICK, R. S. ....State House, Des Moines, Iowa.

HIGGINS, J. E. ....Los Banos College, Laguna, P. I.
HILDRETH, A. C. ....State College of Washington, Pullman, Wash.
HOFFMANN, G. P. .....College of Agriculture, Clemson College, S. C.
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HODGSON, F. R. ....University of California, Berkeley, Calif.
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HOLLISTER, S. P. ,.... Agricultural College, Storrs, Conn.
HOLMES, F. S. ....Experiment Station, College Park, Md.
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HOPPERT, E. H. ....University of Nebraska, Linclon, Neb.
HOSHINO, YUZO ....The Tohoku Imperial University, Sapporo, Japan.
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HOWARD, W. L. ....University Farm, Davis, Calif.
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HOWLETT, F. S. ....Cornell University, Ithaca, N. Y.
HUELSON, W. A. ....University of Illinois, Urbana, Ill.
HUFFINGTON, J. M. ....College of Agriculture, Clemson College, S. C.
HUSMANN, F. L. ......Second and Seminary Streets, Napa, Calif.
HUSMANN, G. C. ......Agricultural College, Amherst, Mass.

ISBELL, C. L. ....Alabama Polytechnic Institute, Auburn, Ala.

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JOHNSTON, S. M. ......Experiment Station, South Haven, Mich.
JONES, H. A. ....University Farm School, Davis, Calif.

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REEVES, F. S. ....Newton Cross, Prince Edward Island, Canada.
REHDER, ALFRED ....Arnold Arboretum, Jamaica Plain, Mass.
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ROSA, JR., J. T. ....University Farm, Davis, Calif.
ROSS, HUGH ....Miller School, Va.

SANDSTEN, E. P. ....Agricultural College, Fort Collins, Colo.
SAX, KARL ....University of Maine, Orono, Me.
SAYRE, C. B. ....University of Illinois, Urbana, Ill.
SCHERMERHORN, L. C. ..Experiment Station, New Brunswick, N. J.
SCHILLETER, J. C. ......Iowa State College, Ames, Iowa.
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SCHUSTER, C. E. ....Agricultural College, Corvallis, Ore.

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SHAW, P. J. ....Agricultural College, Truro, N. S.
SHIMA, Y. ....Kuroishi Agricultural Experiment Station, Aomoriken, Japan.
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THOMPSON, H. C. ......Cornell University, Ithaca, N. Y.
TIEDJENS, V. A. ....Market Gardeners' Field Station, Lexington, Mass.
TOMPKINS, C. M. ......Agricultural College, Fort Collins, Colo.
TUFTS, W. P. ....University Farm School, Davis, Calif.
TUKEY, H. B. ....Experiment Station, Geneva, N. Y.
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WARING, J. H. ....Pennsylvania State College, State College, Pa.
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WESTCOURT, F. W. .....John Tarleton Agr. College, Stephensville, Texas.
WESTOVER, K. C. ......West Virginia University, Morgantown, W. Va.
WHITEHOUSE, W. E. ...University of Maryland, College Park, Md.
WHITMIRE, J. S. ......University of Illinois, Urbana, Ill.
WILDON, C. E. ....Agricultural College, Kingston, R. I.
WIGGINS, C. C. ....University of Nebraska, Lincoln, Neb.
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WOODBURY, C. G. ......National Canners Association, Washington, D. C.
WORK, PAUL ....Cornell University, Ithaca, N. Y.

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